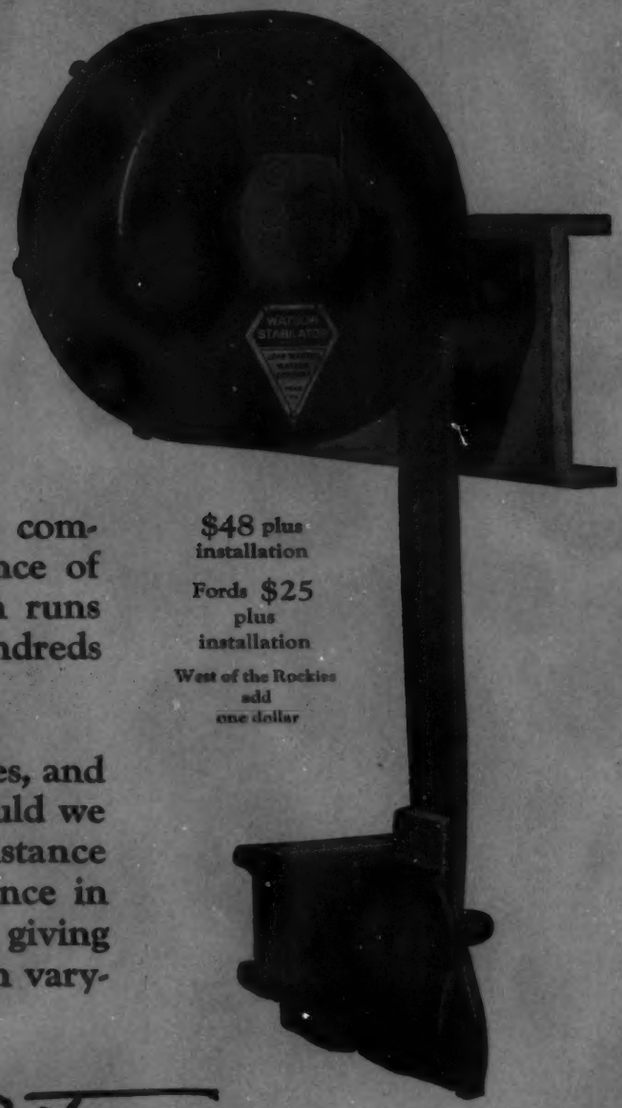
JAN 10 1925

VOL. XVI NO. 1

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

JANUARY 1925

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK



Each greater extent of spring compression means a greater violence of spring rebound. The variation runs from a few ounces to many hundreds of pounds.

To control these different forces, and control each one correctly, should we use a brake giving the same resistance for each, a brake giving resistance in inverse ratio to each, or a brake giving resistance in proportion to each varying force?

$48 plus installation

Fords $25 plus installation

West of the Rockies add one dollar

President

John Warren Watson Company
Twenty-fourth and Locust Streets
Philadelphia

(*Detroit Branch:* 51-53 Canfield Avenue, East)

WATSON STABILATORS

THEY WORK

Engin. Direct

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XVI January, 1925 No. 1

Chronicle and Comment

Dilution Measurement

AN improved method for crankcase-oil dilution evaluation is among the most interesting of recent developments from the cooperative fuel-research. An explanation of the method prepared by T. S. Sligh, Jr., Bureau of Standards, is printed on p. 17 of this issue.

It is believed that the advantages possessed by the new transition procedure of vacuum distillation amply justify its careful consideration by engineers and experimenters whose interests lie in this field. Lack of agreement among technologists as to the best manner of measuring dilution has resulted in a non-uniformity of test results that has hindered intelligent comparison of reports from different sources. It is hoped that the transition method may be generally acceptable.

New Jersey Motorcoach Regulations

ON p. 28 of this issue will be found the motorcoach regulations approved by the New Jersey State Board of Public Utility Commissioners, and also the discussion that took place at the final hearing held in Trenton on Nov. 25.

The regulations and the discussion are of special interest in view of the fact that New Jersey is the first State to develop definite requirements governing motorcoach body and chassis design.

The regulations proposed by the Society's Motorcoach Committee were given in the December issue of THE JOURNAL. They are intended to serve as a basis for motorcoach regulations that may be enacted by various State and local authorities. Recommendations submitted to such authorities will naturally carry more weight when they represent the opinion of a committee of experts of a recognized organization, as is the case in this instance.

American Aeronautical Safety-Code

THE abstract on p. 25 of this issue of the proposed American Aeronautical Safety-Code that has been developed by the Sectional Committee sponsored by the Bureau of Standards and the Society will give those interested in aeronautics an excellent idea of the scope of this Safety Code.

It is to be expected that the application of aeronautics to commercial use will develop more surely when the experimental stages in its progress are passed and a fund of generally acceptable standards is established.

To foster this development it is desirable not only to establish practice along lines which are safe, but also to have that practice as uniform as possible throughout the entire Nation, since the art is one involving flights over extensive reaches of territory.

The Aeronautical Safety-Code will serve as a standard of safe practice for aircraft users and manufacturers and will be available as a guide to legislative regulation.

Braking and Safety

AS a result of several months' activity, the Bureau of Standards and the American Automobile Association, sponsors for a safety code on automobile brakes and brake testing, have prepared a tentative code that was presented as a basis for discussion by the Sectional Committee that met in the City of Washington on Dec. 16.

The Sectional Committee found it impossible at the first session to give adequate consideration to all details of the code. It did, however, approve of 50 and 75 ft. as suitable stopping-distance requirements from a speed of 20 m.p.h. for foot-brakes and hand-brakes respectively, these recommendations applying to passenger cars carrying not more than seven passengers.

The committee decided to continue the investigations applying to motorbuses and trucks with a view to studying methods of making service tests, the effect of loading and related problems.

The tentative code, together with statements concerning justification for the various items, is printed on p. 19 of this issue of THE JOURNAL.

Government Simplified Practice

SESSIONS were held last month at the Department of Commerce in the City of Washington on the subject of the simplification of brake-lining sizes, spark-plug-shell dimensions and piston-ring sizes. R. M. Hudson, chief of the Division of Simplified Practice, presided, about 40 representatives of motor-vehicle and parts manufacturers and of interested associations, including the Society, being present.

The purpose of the Department of Commerce is to encourage simplification in practice, this to be exempli-

fied by the support of the industry of the minimum number of sizes of commodities that will meet reasonable demands.

The extent and the scope of the engineering standardization that has been conducted in the automotive field for a score of years naturally distinguishes this field in this respect from most other industries. All of the subjects that were scheduled for discussion at the December sessions of the Division of Simplified Practice have been studied by the Standards Committee of the Society for many years. The Society's standard of oversize cylinders was established 12 years ago. About 80 per cent of the total volume of brake-lining sold in the year 1923 was in sizes that were standardized by the Society 4 years ago. The standard list now consists of 18 sizes. It has been proposed that this list be extended to include certain sizes for replacement and for vehicles of relatively new types such as the motorbus. The 7/8-18 spark-plug thread was the first standard adopted by the automobile industry. It appears that very little if any addition can be made to the present S.A.E. standard dimensions of spark-plug shells. The Society standard for the minimum length of shell below the plug shoulder is used by 75 per cent of the motor-vehicle manufacturers.

No disposition is apparent on the part of the Government to confuse conditions by doing standardization work itself. The active interest of the Government should result in greater understanding and use of standards sponsored by the industry.

Motor-Vehicle Construction and Highway Safety

SECRETARY HOOVER, in addressing the National Conference on Street and Highway Safety at the Department of Commerce last month, said that highway travel is not safe now for either the pedestrian or the motor-vehicle passenger.

The automobiles in active use in this Country probably transport more people daily than do our railways. The crisis in our street and highway traffic must be met at once in such a manner as to leave no uncertainty as to permanent corrective measures.

The Secretary praised the eight committees of the Conference for their determination and devotion in ascertaining the facts of the situation. The various proposals contained in the report of the Conference, which is printed substantially in full elsewhere in this issue of THE JOURNAL, range from town planning and traffic planning, regulation and legislation to engineering construction and education.

The Motor-Vehicle Committee of the Conference, of which President Crane is chairman, was strongly of the opinion that laws should be drafted so as to include only those features that must be authorized by legislation, leaving to an adequate staff qualified by training and experience the matter of enforcing regulations regarding design, construction, inspection and maintenance of motor vehicles.

The members will be interested particularly in the recommendations made with regard to structural elements. It will be noted that tentative recommendations are made regarding the braking ability of motor vehicles. Limits of allowable play in steering-wheels and of toe-in of front wheels are specified. Driver-vision is discussed. Attention is urged to locating the engine accelerator pedal at a sufficient distance from the brake pedal to minimize the danger of applying the accelerator when intending to actuate the brake. The brake pedal should be constructed so as to minimize the danger of the driver's foot slipping from it when he wishes to actuate it. In vehicles in which it is intended that the accelerator pedal and the brake pedal shall be operated by the same foot, the movement of the foot from the accelerator to the brake pedal should be as easy and direct as possible.

Further recommendations are that motor vehicles be designed so as to permit braking with the engine; that service-brakes be constructed so as to be capable of simple and safe adjustment by the operator throughout the life of the wearing parts; that ratchets of hand-brakes should be installed so as to have greater durability and certainty of operation; and that unintended lubrication should not reach the braking surfaces.

The purpose of the Department of Commerce is to facilitate the coordinating of existing agencies willing to do and capable of doing effective work in solving the various phases of the highway safety problem. The members are asked to give their full support and hearty assistance to the movement.

RAILROAD TRANSPORTATION DEVELOPMENT

OUR railroad freight traffic has increased by the tremendous amount of more than 800 per cent in the last 40 years and has more than doubled itself in the last 20. It has increased at a rate well in advance of the population increase, because the requirements of our own people and of our foreign trade have been developed to a marked degree by the unprecedented inventions and the advance in civilization of recent decades. That we, as a people, are living far better than our forefathers did is demonstrated by our increased dependence upon transportation; that we are doing more and more business with our neighbors all the time is indicated by the increase in our export traffic, well aside from the artificial increase occasioned by the war.

Despite the disturbances incident to the World War, railroad freight traffic per mile of line had climbed by 1923 to a level approximately 36 per cent above that of 1913, a normal year prior to the war. In the same period the investment in property per mile of line had increased only 31 per cent. The total tractive power of locomotives had increased only 30 per cent and the total capacity of freight cars only 18 per cent.

It has been estimated that if railroad traffic increases in the next ten years only half of what it did in the last 10, an expenditure of approximately $800,000,000 per year above the ordinary maintenance will be required steadily for the next 10 years to keep pace with the growth of business. Operating expenses have been reduced nearly $5,000,000 a day in the last 4 years, while at the same time a great increase has been made in the ability of the railroads to handle the business offered them. Less than one-fourth of this saving in operating expenses has been made through reduction of wages from their war-time level.—From an address by President Markham, of the Illinois Central Railroad Co., before the Association of Life Insurance Presidents.

MEETINGS OF THE SOCIETY

ANNUAL MEETING IN DETROIT

Extremely Interesting and Instructive Exhibits Form Part of Program There

Study of the Annual Meeting program published on the next page should convince anyone having a live interest in automotive engineering subjects that a trip to Detroit Jan. 19 to 22 will be a profitable educational investment. While the papers will appeal primarily to passenger-car engineers, there is considerable in the program to interest all members of the automotive engineering profession.

The 1925 Annual Meeting will be unique in one respect; an unusually comprehensive group of demonstrations and exhibits will supplement the speaking program. These, in themselves, will be well worth the time and expense of attendance. Actual determinations of the degree of dilution in a sample of crankcase oil will be made by members of the Bureau of Standards research staff with apparatus recommended by them for a standard method of dilution determination.

In the Air-Cleaner Session there will be many exhibits of parts taken from engines tested in actual service, with and without air-cleaners, to determine the relative wear under these conditions. A celluloid model of a cleaner built by the General Motors Research laboratory workers will be shown in action, so that the members may actually see the path of the dust as it is separated from the airstream. Other apparatus from the General Motors laboratory will be used to demonstrate theories applicable to the air-cleaning subject.

In connection with the papers on aviation, there will be exhibits of airplane and airplane engine parts. The latter will be taken from one of the most recently designed aviation engines and will be shown alongside those from the Liberty engine of wartime fame. Inspection of this exhibit will give a graphic picture of progress since the Armistice. There will be many representative parts taken from the structure of a commercial airplane constructed entirely of metal.

A Full Study of Wheel-Shimmy

Wheel-shimmy has been a perplexing problem to many automotive engineers these last few months. In the Wheel-Shimmy Session, they can hear several papers on the subject, each of which will be copiously illustrated with photographs, slides and actual models of devices designed to counteract the shimmying tendency. One of these will be a hydraulic steering gear. Ingenious recording instruments that make a quantitative record of the stresses in steering-wheels, steering cross-tubes and other units in the steering system while a car is being driven over the road will be exhibited and demonstrated by one of the speakers in this session.

Steel parts taken from one of the latest types of all-steel automobile bodies will be shown in one of the Body Sessions. These will include sills, pillars, door framing and the like. There will be a paper on the Weymann type of body that employs a unique construction in its framing and substitutes enameled cloth for all of the metal door, cowl and body panels.

In the Research Session there will be a description of a great many ingenious instruments, recording devices and testing apparatus employed in research laboratories throughout the automobile and related industries. It is probable that some of these will be displayed at the meeting.

A Rubber Crankshaft

Engineers have spoken jokingly of rubber crankshafts when discussing engines that vibrate badly. At the Annual Meeting session devoted to crankshaft vibration studies, there will be shown a rubber crankshaft, molded in the forging die of a six-throw shaft. It will be used by the speaker to illustrate how crankshafts bend in actual use. Another model will illustrate to the audience by indicator flags just what effect is produced upon the balance of a shaft when suitable counterbalancing weights are employed.

One of the most interesting demonstrations planned is that with a specially prepared four-cylinder engine, motor driven, and so connected with tilting mirrors that the character of four-cylinder vibration can be seen in its relation to the speed of the engine and to the natural frequency of vibration of the mounting.

In the Balloon Tire Session, such matters as excessive tread-wear, punctures and blow-outs, jouncing or galloping, rim sections and inflation-pressures will be discussed by authorities. Many prominent car and tire engineers will contribute their views.

All sessions of the Annual Meeting will be held in the assembly rooms on the 15th floor of the General Motors Building in Detroit. Admission will be granted to the entire membership, of course, and to those non-members who pay the registration fee of $2. Because of the intensely interesting program of papers and demonstrations, it is expected that the attendance will be the largest in the Society's history.

ANNUAL DINNER JAN. 8

Leonard P. Ayres and Dr. A. E. Morgan Will Address Gathering In New York City

On the evening of Jan. 8, at the Astor Hotel in New York City, members of the Society will gather around the banquet table for the Annual Dinner. Held during Automobile Show Week, this function is one of the largest and most congenial formal assemblies of automobile technologists arranged during the year.

THE ANNUAL MEETING PROGRAM

General Motors Building **Detroit, Jan. 19 to 22**

Monday, Jan. 19

2:30 p. m.—Standards Committee Meeting

Tuesday, Jan. 20

9:00 a. m.—Registration and Reception

10:30 a. m.—Research Session
Annual Report of the Research Committee
[1]Research Instruments and Apparatus—J. A. C. Warner

2:30 p. m.—Aviation Session
[1]The Design of All-Metal Airplanes—W. B. Stout
[1]Latest Developments in Aircraft Engines—L. M. Woolson.

2:30 p.m.—Passenger-Car Body Session
[2]All-Metal Body Design and Construction—E. G. Budd and J. Ledwinka

7:30 p. m.—General Session
Presidential Address.—H. M. Crane
[1]Measurement of Engine Vibration Phenomena—C. E. Summers

Wednesday, Jan. 21

9:30 a.m.—Steering and Wheel-Shimmy Session
An Analysis of the Wheel-Shimmy Problem—
(*a*) W. R. Strickland
(*b*) Otto M. Burkhardt
[1]Forces and Stresses in Steering Systems—F. F. Chandler and H. A. Huebotter
[1]Possible Causes of Wheel Shimmy—J. W. White

2:30 p. m.—Balloon Tire Session
[2]Relation of Balloon Tires to the Wheel-Shimmy Problem—R. B. Day
Advances in the Design of Balloon Tires—B. J. Lemon
A Car Manufacturer's Experience with Balloon Tires—E. A. DeWaters

2:30 p. m.—Passenger-Car Body Session
The Weymann Method of Body Construction—George E. Kerr
The Relation of the Custom Body-Builder to the Car Producer—J. B. Judkins

9:00 p. m.—THE CARNIVAL—ORIOLE TERRACE
All tables reserved. Tickets must be purchased in advance. Members, $6; ladies, $6; non-members, $7

Thursday, Jan. 22

10:30 a. m.—Air-Cleaner Session
[1]Physical Characteristics of Road and Field Dust—C. E. Summers
[1]Air-Cleaner Investigations—Prof. A. H. Hoffman
(*a*) Final Data on University of California 1924 Cleaner Tests
(*b*) Relative Wear Tests with and without Cleaners

2:00 p. m.—Lubrication Session
Foreign Material in Engine Oil—Its Character and Effect on Engine Design—G. A Round
[1]Investigations of Crankcase-Oil Dilution at the Bureau of Standards—S. W. Sparrow.
[1]A Standard Method for Determining the Degree of Dilution in Crankcase Oil—T. S. Sligh, Jr.

8:00 p. m.—An Analysis of Vapor-Cooling Systems for Automotive Engines—N. S. Diamant

[1]Exhibits, models or demonstrations will be an important part of the presentation of these papers

[2]Motion pictures will be used as part of the presentation of these papers

Col. Leonard P. Ayres, economic and financial authority of note, will give one of the principal after-dinner talks. His topic will be the automotive business situation in 1925. Dr. A. E. Morgan, a prominent civil engineer now turned educator, will present some novel conceptions of an adequate college training. He will describe the educational methods employed at Antioch College, of which he is president.

Past-President C. F. Kettering will act as toastmaster of the Annual Dinner and there will be brief talks by President Crane and H. L. Horning, presidential nominee. Strickland Gillilan, humorist, will close the speaking program. An elaborate musical program has been arranged. All members resident in continental America have received blanks that should be used in ordering tickets.

THE 1925 CARNIVAL

Automotive engineers, usually serious and retiring in demeanor, will cut loose the ties of propriety and step forth on a gay mission of frivolity in Detroit on the evening of Jan. 21. For that is the night of the far-famed and popular S.A.E. Carnival. Oriole Terrace, Detroit's largest and finest home of Terpsichorean devotees, will throw wide its doors and bid enter the technicians, the near-technicians and the fair sex of motordom. Decked in gay colors, its white-linened tables looking pale in the setting of vivid bunting, figures and varicolored lights, Oriole Terrace will house a frolicking crowd of slide-rule manipulators. Syncopation will be King.

Tickets will be $6 for members, $6 for ladies and $7 for non-member guests. Each member will be entitled to purchase but one non-member ticket. Ticket order blanks have been mailed to the entire membership in the United States and Canada. All orders must be mailed to the New York City office of the Society until Jan. 15 and thereafter to the Detroit Section office, 5-110 General Motors Building, Detroit.

PETROLEUM INSTITUTE MEETS

Fuel Utilization and Lubrication Discussed; Cooperative Tests Reported

"Good gasoline," a topic that always excites interest, invariably comes in for its full quota of discussion at meetings of the American Petroleum Institute where petroleum and automotive engineers gather each year to consider technical problems of common concern. The fifth annual session, held at Fort Worth, Tex., Dec. 9 to 11, offered no exception in this regard. Progress in the cooperative fuel investigation was reported, a new method for dilution evaluation was announced and many phases of the fuel-utilization and lubrication problems were considered in detail.

Progress In Cooperative Research

Crankcase-oil contamination was the principal subject reported in a review of progress in the fuel research now under way at the Bureau of Standards in cooperation with the American Petroleum Institute, the National Automobile

Chamber of Commerce and the Society of Automotive Engineers.

The work of the past year has resulted in (*a*) the development of a satisfactory method for measuring dilution, (*b*) the statement of a reasonable explanation of the mechanism of dilution and (*c*) the establishment of much additional information relating to the factors that influence the rate of dilution.

The investigation has substantiated the conclusions that under average operating conditions crankcase-oil dilution (*a*) depends primarily on the average temperature of the cylinder-walls, (*b*) is likely to reach an equilibrium value if starting periods are not too frequent, (*c*) depends directly on fuel volatility, (*d*) depends directly on the average fuel-air ratio, (*e*) does not depend much upon the piston temperature and (*f*) does not depend much upon the charge temperature or the degree of vaporization.

The progress report above summarized was prepared by Dr. H. C. Dickinson and S. W. Sparrow. It was presented by H. K. Griffin, who also read a paper by T. S. Sligh, Jr., of the Bureau of Standards, on the measurement of crankcase-oil dilution by the vacuum distillation transition method. Mr. Sligh's paper is printed on p. 17 of this issue.

Engine For Oil Or Oil For Engine

> Why should not an engine be designed around an oil that should be used rather than to try to find an oil to suit an engine after it is built? In other words, is it not feasible to adapt an engine to any desired oil by proper regulation of the rate of oil circulation to secure a normal oil consumption? By this means, it should be at least possible to eliminate the necessity for using oils of such high viscosity that they are too sluggish to flow in a cold engine, and that usually leave large carbon deposits.

Thus, Neil MacCoull, of the Texas Co., injected an interesting idea into his paper on fuel utilization and lubrication problems.

With further reference to lubrication and design, Mr. MacCoull stated:

> I look forward to the day when any *good* car can be expected to cover at least 100,000 miles with no mechanical attention to the engine.

Getting "the right oil in the right quantity to the right place at the right time" is the ideal toward which engineers and designers should direct their efforts.

In commenting upon full-pressure lubricating systems, the speaker emphasized the faults of the spring-loaded regulating valve. He said:

> When the oil is cold, a very high pressure is necessary to force the normal volume of oil through the bearings. But before the pump can build-up such a pressure, the by-pass valve opens and releases most of the oil back into the crankcase. Consequently, while the oil is cold, very little passes through the bearings, and naturally very much less reaches the cylinder than normally. . . . . I cannot see why a more or less constant pressure should be sought after instead of a constant volume per revolution. Let the oil-pump act like a meter, make it the right size, and let the pressure required to deliver that volume go where it will. If adjustment of the rate of circulation is needed for varying piston-ring fits, this can be done nicely by the use of an open orifice in place of the spring-loaded valve.

Relative to fuel utilization, mention was made of the possibility of refining a straight fuel that, because of its composition, will allow higher engine-compressions without detonation. Attention was directed to the fact that equal suppression of detonation results from the introduction of 30 per cent of water, 12 per cent of benzol or 1/20 per cent of tetra-ethyl lead.

Mr. MacCoull concluded his paper with comments on typical lubricating systems and with descriptive material relating to various types of manifold, induction heating devices, rectifiers, air and oil filters.

Special Winter Fuels Advocated

That the introduction of special winter fuels has met with widespread approval and is to be recommended was the opinion expressed by J. A. C. Warner, the Society's research manager, in his paper entitled Automotive Fuel Observations. Considerable evidence was offered in support of this belief.

"Power availability" was said to be the principal factor that influences the average driver's choice of a fuel. This fact was clearly emphasized by the results of the cooperative winter road-tests of fuels in which 10 leading automobile companies participated under the sponsorship of the American Petroleum Institute, the Bureau of Standards, the National Automobile Chamber of Commerce and the Society of Automotive Engineers. Acceleration and starting characteristics of the four fuels tested were the features that influenced the order of choice. Drivers were remarkably consistent in selecting the best and the worst fuels on this basis.

Other conclusions presented in Mr. Warner's paper were: (*a*) in the matter of dilution, which is apparently largely influenced by the upper part of the distillation range, the average motor-vehicle operator has no effective and ready means of warning of impending difficulties that may arise from excessive dilution and thus he is largely at the mercy of the fuel supplier in this regard; (*b*) dirt and dilution go hand-in-hand throughout the general problem of oil contamination and both factors must be given due consideration; (*c*) sufficient evidence has been gathered by the Fuels Group of the Society's Research Committee to indicate the desirability of devoting added attention to the question of permissible sulphur-content of motor fuels; (*d*) Bureau of Standards tests have shown that none of the fuel dopes or doped fuels thus far studied has produced any appreciable improvement in power or fuel consumption, provided no detonation was present when using the untreated gasoline since dopes that are beneficial derive their value from their influence upon detonation; (*e*) Bureau of Standards tests have shown that the influence of running an engine under load is marked insofar as the removal of carbon deposits is concerned and (*f*) outstanding fuel problems are of common interest to the automotive and the petroleum engineers alike, and can best be handled through concerted effort. The primary object should be that of maintaining a proper balance between the automotive equipment and the fuel available.

Tetra-Ethyl-Lead Hazards

Thomas Midgley, Jr., of the Ethyl Gasoline Corporation, in speaking of the health hazards associated with tetra-ethyl lead asserted that the casualties that have developed in the manufacture of this compound offer no more reason for avoiding the use of ethylized gasoline than mine catastrophes justify stopping the use of coal. Extensive tests at the Bureau of Mines were cited to show that no dangers are connected with the use of the fuel.

Mr. Midgley stated that the five persons who recently died in New Jersey after assisting in the development of a new and untried process of manufacturing the concentrated tetra-ethyl-lead compound gave their lives to the cause of scientific progress.

Over-Production

Thomas O'Donnell, retiring president of the Institute, delivered an address dealing with the general situation in the petroleum industry. He advocated a policy of "no Government meddling in the oil industry's ills" and believed that "the temporary growing pains of over-production" could be relieved from within rather than through outside interference. Henry L. Doherty, president of the H. L. Doherty Co., on the other hand advocated a unit development plan of control calculated to effect petroleum conservation.

Charles E. Mitchell, president of the National City Bank of New York, summarized the financial aspects of the oil situation in his address, "Facing Facts in Petroleum," and Walter C. Teagle, president of the Standard Oil Co. of New Jersey, presented a very clear analysis of over-production matters in a paper entitled "Over-Production, Its Causes and

Effects." At the general and group sessions many technical subjects of peculiar interest to oil men were discussed. Of especial interest to all was a paper on helium by Rear-Admiral Moffett, chief of the Bureau of Aeronautics, Navy Department, in which the plea was made that the petroleum industry take over the commercial production of helium now that the Government has brought it satisfactorily through the development stages. Lieutenant-Commander Wicks presented the paper in the absence of Admiral Moffett.

J. Edgar Pew Elected President

J. Edgar Pew, vice-president of the Sun Oil Co., was elected president of the Institute to succeed Thomas O'Donnell, who has held the office since the Institute was established.

California was chosen as the next meeting place.

Public Relations

For accomplishing the regular and systematic publication of reliable information concerning the petroleum business, a public relations committee was formed and authorization was granted for that committee to raise by private subscriptions a special fund of $100,000 per year for its use and maintenance.

MAINTENANCE AND FLAT REPAIR-RATES

Businesslike Service-Methods and Successful Flat-Rate Practice Analyzed

Success attained by following consistent policies of educating employes for their duties and of giving value, dollar for dollar, on all work done for car-owners, was reported in detail by two companies at the meeting of the Milwaukee Section held on Dec. 10. C. D. Prinz, service-manager of the Packard Motor Car Co., presented a paper entitled Service Problems Confronting the Distributor and the Dealer; and Matthew Kissinger, of the Wisconsin Magneto Co., Milwaukee, told what the flat-rate system had accomplished for his company by its application to electrical repairs.

"Service" means *maintenance*, said Mr. Prinz. It represents an earnest endeavor on the part of car builders, distributors and dealers to give the car-owner good value in maintenance, for value received and in a businesslike manner, and there is nothing "free" about it. Car-owners, by having become car-owners, pay the bills and the salaries of the automotive industry, and they determine whether its business is good or bad.

Sales and service now go hand in hand. Salesmen should talk maintenance methods, charges and efficiency to prospective buyers. Thus, a salesman sells the product once. But the maintenance department must sell and continue to sell maintenance in a manner that will assure satisfaction to all customers at all times.

Faulty design, faulty production, maintenance-department incompetency, incapacity of the car-owner and the wear-and-tear of normal car-usage are the five reasons that explain the car-owner's need for adequate maintenance of his car. The first three are within the control of the builder; the last two, within that of the owner.

Time saved by better design and greater accessibility was tellingly illustrated by Mr. Prinz when he cited repairs of similar nature made to a 1914 and to a 1924-model car; the former consumed 9 hr., the latter, 2 hr.

Proper design and systematic and rigid inspection will correct faults of production. Incompetence flees from an adequate campaign to educate and train all employes.

Mr. Prinz remarked that the automobile gets more abuse and less attention from its owners than any other mechanical product that is in general public use. He advises car-owners to study the instruction book furnished with the car, and to follow out a regular schedule regarding lubricating oil, gasoline and change of engine oil. Systematic inspection by the owner, for maladjustment of parts, is also needed. In conclusion, he exclaimed over how *abnormal* much of the supposed "normal car-usage" is, and pointed out how heavily wear-and-tear on the machine increases in such a case. Contrary to public impression, a maintenance department pays only fairly well. The average net return on the investment for maintenance of all United States dealers and distributors was but 3.5 per cent for 1923. Mr. Prinz believes the flat-rate system for repair charges will become general, because it is the only method known that will control the time limit on all maintenance operations.

Flat Rates For Electrical Repairs

Best results for the customer, for the employes and for the company are attained by Mr. Kissinger's organization through its policy of educating the employes and treating them considerately. To lower costs to the customer, increase the company's return on its investment and raise the pay of the employes, this company installed a flat-rate system. Time studies determined its selling prices. One of the results was a reduction of 15 per cent in the average cost of a job. Another was that, at a mechanic's rate of 75 cents per hr., the company can now pay that mechanic 35 per cent of the flat-rate receipts, increasing this man's income 22 per cent and adding to the company's income 20 per cent, based on the same number of hours.

Mr. Kissinger gave interesting details of the methods used in arriving at routine procedure and satisfactory shop practice, giving details also of order forms and company records.

In the discussion that followed, Mr. Kissinger mentioned that the flat-rate plan practically has eliminated the item "lost time" in the busiest months and has made each hour productive. The necessity for adequate maintenance equipment, including special tools, was emphasized by Mr. Prinz. It was stated also by one of the discussers that the success of the flat-rate system depends largely upon proper and adequate inspection methods and the capabilities of the inspectors; the personality of the man who meets and deals with the customers has an important influence. Not only must this man talk tactfully and intelligently, but he must be able to diagnose the trouble correctly from the description given him by the customer.

CHICAGO SECTION INSPECTS LABORATORY

Underwriters' Representative Testing Methods Demonstrated Spectacularly

Maintained to devise and carry out tests of different devices and construction elements in their relations to insurance risks, under normal conditions of service and when subjected to the hazards that they are expected to withstand, Underwriters' Laboratories, Inc., Chicago, as explained by Dana Pierce, its president, to the members and guests who attended the Chicago Section meeting held on Dec. 19, secures these data and makes the information available for insurance purposes. Following the lively luncheon served at a famous Chicago café to the 88 people who were wise enough to come to the party, a luncheon made still livelier by professional entertainers and peppy music, all the Society participants were graduated to the Laboratories' plant, there to be initiated into its mysteries.

As reported by F. C. Mock of the Stromberg Motor Devices Co., Chicago, it was explained by Mr. Pierce that the difference between the viewpoint of the designing engineers and that of the Laboratories lies in the fact that such engineers are specialists in construction, while the Laboratory engineers are specialists in destruction, although governed by a constructive purpose. The Laboratories also specializes in a continuous inspection of production material, and maintains this service on products for the market that bear its approved label.

Numerous tests had been grouped for demonstration. Among these, the most spectacular were: a fire test of a large panel of gypsum board, the cutting through with an oxygen flame of a 6-in. steel-plate bank-vault wall in 45 sec., several fire extinguishing tests and the destruction of an

automobile bumper by an impact at its center equal to that of a 3000-lb. car striking a solid obstacle at a speed of 6 m.p.h. Other tests especially interesting to automotive engineers were: explosion tests of mufflers; vibration tests of horns, ammeters and gasoline gages; durability tests of locking cylinders for automobile locking devices; durability tests of switches for coincidental locks, and corona tests of high-tension ignition wire.

EUROPEAN AUTOMOTIVE PRACTICE

Features of Recent English and French Shows Outlined for Pennsylvania Section

B. B. BACHMAN

Impressions of the present status of the automotive industry in England and in France, gathered during his recent trip abroad, were outlined most entertainingly and instructively, at the meeting of the Pennsylvania Section held on Dec. 9, by B. B. Bachman of the Autocar Co., Ardmore, Pa., and former president of the Society. In addition to attending the Olympia passenger-car show in London, as well as the passenger car and the truck shows in Paris, Mr. Bachman visited numerous automotive plants and saw the permanent exhibition of motor trucks in the British Empire Exposition at Wembley.

Subjects of interest to Mr. Bachman while in the manufacturing plants in England included, regarding one near Manchester, the apparent lack of cohesion of the plant units and the conveyance of an impression that the factory had grown-up in spots; in another, thirty-five miles from London, that the company makes motor trucks, motorbuses, motor fire-apparatus and power-driven lawn-mowers, and makes also practically everything it needs for its own uses. One company in Coventry has its well equipped machine shops in old buildings in the town, and its modern and excellent assembly plant several miles from the town; this involves an interesting transportation problem between the plants. Another company in the same locality has laid plans to enter the field of the popular-price car and expects to build during the coming year some 40,000 cars of two models having 10 and 14 hp. respectively; many of the parts of each model are interchangeable with those of the other, and the company has installed special machinery.

Describing the manufacturing plant and the rebuilding plant of the London General Omnibus Co., Mr. Bachman said that the motorbuses manufactured are of a rather special type due to the very severe police restrictions on design features that are imposed on motorbuses operated in London. The Chiswick rebuilding plant is new and was designed to enable this company to rebuild its entire fleet of vehicles once each year. One drawback of this policy lies in the impossibility of determining what the actual life of a vehicle is, because interchangeable parts are substituted during the rebuilding process. But, in general, the repair business in England appears to Mr. Bachman to be less completely organized when compared with conditions in the United States.

AUTOMOBILE AND MOTOR-TRUCK SHOWS

Although he characterizes the shows as having been somewhat disappointing in their failure to exhibit more novel or more radical departures from accepted motor-vehicle design, he observed many interesting features of present European practice.

Use of aluminum pistons appears more general abroad than here. Drop forgings are being used increasingly. But slight attention seems to be paid to heat regulation of the fuel mixture. Gasoline in London and in Paris gave satisfactory performance; a London sample showed an initial-point in distillation of 30 deg. cent. (86 deg. fahr.) and an end-point of 183.0 deg. cent. (361.4 deg. fahr.). Magneto ignition is used almost entirely. Few air-cooled engine are in evidence. The Hotchkiss drive is used to a considerable extent. Rear axles on passenger cars are mostly of the conventional spiral-bevel type; one truck model has a single-reduction spiral-bevel, but the double-reduction has greater usage in Europe than in this Country. Right-hand control of cars is in very general use on the continent, which is surprising because a right-hand rule-of-the-road prevails there.

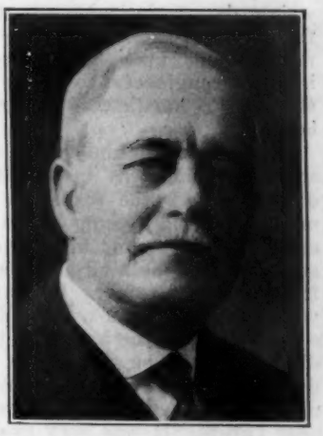
Four-wheel brakes are in almost general use in France, but this is not true in England. Methods of equalization are varied. Servo-mechanisms are generally used on the larger cars. No examples of hydraulically operated brakes produced in England or in France were noted. Exhibits indicate that balloon tires are standard equipment. Disc wheels on trucks, with twin-tire equipment, are common. Platform heights of motorbuses are generally greater than ours and four-cylinder motorbus-engines are employed. French and Italian motorbuses exhibit a distinct tendency to use four-wheel brakes.

Before leaving England Mr. Bachman visited Harry R. Ricardo's research laboratory at Shoreham-by-the-sea and was cordially received by Mr. Ricardo, who has excellent facilities for conducting his investigations relating to the internal-combustion engine.

Numerous queries from representative members and guests present elicited further valuable information from Mr. Bachman, following his address.

MOTOR-TRUCK LEGISLATION

New Massachusetts Regulations Explained by Commissioner at Boston



WILLIAM F. WILLIAMS

State regulations affecting motor-truck registration, loads, speeds and markings have recently been established in Massachusetts by the Division of Highways. In view of the tendency for one State to follow the lead of another on matters of legislation, these new rules are of interest to all makers and operators of commercial vehicles. Commissioner William F. Williams of the Massachusetts Department of Public Works addressed a very large audience of truck operators at the December meeting of the New England Section in Boston and explained in detail the significance of the new regulations that have just been issued.

The more important points covered by the Massachusetts highway transport regulations follows:

(1) Every motor vehicle carrying personal property shall have the owner's name plainly marked on each side of the body. The weight of the vehicle without load in pounds, and the registered carrying capacity in tons of 2000 lb., must be plainly marked on each side of the body near the driver's seat in characters not less than ¾ in. in height

(2) The operator of every motor vehicle carrying personal property shall carry a certificate of its weight signed by a sworn weigher. Every vehicle

must be reweighed after any change that affects its unloaded weight

(3) Operators of motor vehicles carrying personal property beyond the limits of any town or city must carry a bill-of-lading or memorandum setting forth the weight of the load of such vehicle

(4) No vehicle may operate upon certain sections of the State highways designated or posted by the Highway Division, the weight of which with its load is in excess of 500 lb. per in. width of tire in contact with the road or in excess of 20,000 lb. total.

Note: The permissible load is 800 lb. per in. width of tire in all other cases

(5) No person shall operate a motor vehicle carrying personal property on any highway when the weight of the load exceeds the carrying capacity for which such vehicle is registered

(6) No person shall operate a motor vehicle carrying personal property on any highway at a speed in excess of 15 m.p.h. if its registered carrying capacity is over 2 tons, or in excess of 20 m.p.h. if its registered capacity is 2 tons or less

Commissioner Williams said that the term "personal property" is employed because it is comprehensive. It includes goods, merchandise, farm products, building materials and every other form of personal property as distinguished from real property. It should be noted that this term does not cover the transport of passengers; hence the rules apply only to what are commonly classed as commercial vehicles.

Weight Data Primarily for Road Design

Considerable discussion was had at the meeting concerning the carrying of bills-of-lading or weight memoranda. Operators present called attention to the case where a vehicle leaves its headquarters empty and travels over a route, picking up small loads at several points and returning with a full load. Commissioner Williams recommended that such a vehicle carry a memorandum of the heaviest load it might be expected to carry on any such trip. He said that the weight data is desired by the Division of Highways primarily for the purpose of compiling accurate estimates of the demands made upon each State highway, thus enabling the highway engineers to build roads of adequate size and strength to handle the traffic that they will be expected to bear.

The regulations under (4) are intended to protect certain sections of highway in the State, notably in the Cape Cod district, where the roads are of a semi-plastic nature and not constructed to support the heavy loads borne by the concrete and other rigid highways. Definite limits of speed are set to protect the highway from excessive shocks rather than for reasons of safety. Commissioner Williams said that he would have included a rule making the fitting of governors compulsory, but he has been unable to determine what conditions should be met by a satisfactory speed-regulating device. This he considers to be an important duty of the motor-vehicle engineer and he hopes for a solution in the near future. It was very evident that the Commissioner is an advocate of some means of automatic speed regulation which is beyond the control of the driver.

Truck operators objected to the ruling that tire width should be interpreted as the width in contact with the road instead of that at the base of the tire. It is evident that this penalizes some cushion and grooved-block forms of tire and allows greater loads on worn solid tires than on the more resilient new ones. The Commissioner stated that the width of a pneumatic tire could be taken as the maximum width of the inflated casing, but he maintained that the regulation with regard to solid and cushion tires must stand.

Use of Anti-Skid Chains Discouraged

While the regulations permit the use of chains on motor-truck wheels, Mr. Williams appealed to the truck operators to dispense with them as often as possible. He expressed the opinion that they do not prevent skidding, although he admitted their value as a means of securing traction. He pleaded for the use of chains that will do as little damage to the road as possible and still provide a reasonable amount of traction.

Another ruling that Commissioner Williams hopes to introduce in the future is one calling for lights on the rear of all vehicle bodies to indicate their extreme width. He believes that present types of rear-view mirrors are inadequate as a means of informing the driver of conditions to the rear of his vehicle.

The Massachusetts Division of Highways has taken over the adequate posting of all highways in the State. All other road marking, danger and direction signs will be removed. Experiments have led to the selection of black letters on an orange background for all road markers. Very simple words will be employed. Only the serious danger points as reflected by accident records will be marked by danger signs. Yellow signal lights are being installed at the right side of all highways, 200 ft. from each railroad crossing. The railroads are to install automatic red danger signals to flash a warning over the intersection of the highway and the tracks. Commissioner Williams commended the scheme of painting white center-lines on all highways as a means of speeding up traffic. The white line serves as a guide for the driver of wide commercial vehicles and he is more likely to keep his truck to the side instead of in the center of the road, thus enabling faster vehicles to pass him without delay.

Motor-vehicle administrators are extremely anxious to adopt an accurate horsepower formula for passenger-car registration purposes, said Mr. Williams. They appreciate that the present National Automobile Chamber of Commerce formula is inadequate and feel that automotive engineers must agree upon a formula that gives a reasonably accurate measure of engine-power.

MODERN AUTOMOTIVE CLUTCH DESIGN

E. E. Wemp's Cleveland Section Paper Contains Valuable Material on Plate Types

A new conception of the function of an automotive clutch, that of a heat-dispersing device, was presented to the Cleveland Section at its meeting on Dec. 15. E. E. Wemp, engineer of the Long Mfg. Co., convinced the members present that a clutch does its most strenuous work during the period of slippage just previous to full engagement. During this period it virtually converts engine torque into heat, which must then be dispersed through the clutch mechanism. Mr. Wemp discussed many important points of clutch design such as friction facings, engagement methods, cooling and thermal efficiency, adjustment, methods of control, lubrication of release sleeves and balancing. An abstract of his paper is given in the following paragraphs.

The development of asbestos-base friction facings has made possible the multiple-disc, dry-plate and single-plate types of clutch. Friction facings are divided into two general classes, molded and woven. The ability to withstand high temperatures is one of the chief assets of the molded facing. Its body is practically pure asbestos, no other substances being present to char or burn out in the curing process or in actual operation. Molded facing answers all the requirements for hard, continuous service and is ideal where serviceability is the paramount consideration. Its density, however, will defeat good engagement unless special means are provided to introduce an element of flexibility in the clutch plates.

Molded Facing Resists Heat Better than Woven

The cotton content of the thread used in woven facings will only stand a limited temperature before charring. This temperature is decidedly below that obtained in severe clutch operation. Comparison of the molded and woven forms of facing shows them to be equal as regards coefficient of fric-

tion and the permeation of the impregnating solution which prolongs the life of the facing. The woven type engages more smoothly, but the molded type has a decided advantage in its higher heat-resisting ability and lesser cost.

Probably the outstanding difficulty to be overcome in the operation of a single-plate clutch is a chattering or grabbing action during engagement. Mr. Wemp said that this trouble can be overcome by providing a certain amount of yieldability in the driven-member unit. Absolute parallelism of the driven member and facings reduces the need for this yielding action but does not obviate it entirely. One method of providing the yielding action is to use a very dense facing of the molded type and provide for the necessary yieldability in the design of the driven disc itself. This method is being employed commercially by several companies.

Making the Clutch Thermally Efficient

Mr. Wemp said that there is one element of clutch design that has not received proper consideration in the past. This is the thermal efficiency of the clutch. Strenuous service in motorbuses has emphasized the importance of having a clutch rid itself of the large amount of heat generated as a result of its frequent usage. The experience of Mr. Wemp, who has done considerable work on this phase of clutch design, has led him to the following conclusions:

(1) If careful consideration is given the question of thermal efficiency, the unit-pressure of the facings is unimportant over a wide range of pressures

(2) As a result of the previous conclusion, it is believed that a single-plate or two-plate clutch is the logical design for heavy-duty service. This is largely because it is much easier to provide for the necessary masses of absorption metal in these clutches than in the multiple-disc type

(3) The masses of absorption metal should be carried as a part of the flywheel weight

(4) Cast iron is the best metal to use as a friction facing for engaging the facing. The free graphitic content of cast iron provides a slight lubricating effect and permits the surfaces to attain a smooth, high polish

(5) With their present knowledge of the subject, the Long engineers attempt to provide two elements for increasing the thermal efficiency of the clutch. A considerable mass of metal is provided in the driving discs and this mass of metal is designed to provide a large exposed area for surface radiation. The mass of metal serves as a reservoir that absorbs a large number of heat units without raising the temperature of the driving disc too quickly

As an aid to radiation, Mr. Wemp recommended that openings be provided in the sides of the bell-housing and that at least one be located near the periphery of the flywheel so that advantage may be taken of the fan action of the revolving flywheel and clutch unit. One of the advantages of the single or two-plate clutch lies in the fact that the flywheel itself constitutes a driving disc and absorbs directly 50 per cent of the heat liberated in the single-plate type and 25 per cent in the two-plate type.

Balancing of Clutches Important

In Mr. Wemp's opinion, it would appear that non-adjustable forms of clutch are practicable for engines developing not over 2000 lb-in. torque. Above this capacity, either the driven-disc diameter must be so large as to handicap shifting or the pedal pressure must be excessive. While both push and pull types of clutch control are in general use, Mr. Wemp said that the tendency is toward favoring the push type, particularly in single-plate designs. The efforts of motor-car manufacturers to reduce vibration in engines is necessitating the balancing of clutch units. A 20-lb. clutch will produce an unbalance of 0.32 in-lb. for each 0.001 in. of eccentricity of its center of gravity. One of the most serious phases of the situation lies in the fact that adjustment of the clutch may require an angular rotation of some members of the clutch assembly which may cause an unbalance.

Mr. Wemp made some predictions regarding clutch development in the future. He believes that the use of single-plate clutches will increase. This will be accompanied by improvements in present designs, effecting better operation and increased durability. A suggestion along this line would be the development of a friction facing, capable of high heat resistance, whose coefficient of friction is greatly in excess of that of existing facings. A single-plate clutch may be perfected which obviates the necessity of a sliding spline fit between the clutch-hub and the driven shaft. Some simple means will be developed for damping vibration between the

SCHEDULE OF SECTIONS MEETINGS

JANUARY

2—Washington Section—Lubrication—Neil MacCoull
6—Buffalo Section—Correct Lubrication—E. W. Kimball
9—Los Angeles Group—Six-Wheel Trucks and Their Effect on the Road—Ethelbert Favary
14—Dayton Section—The Cab and the Motorbus—G. A. Green
14—New England Section—(Boston) Engine Governors—Edward P. Low
15—Detroit Section—Round Table Discussion for Chief Inspectors and Men Interested in Inspection Work
15—Indiana Section—Lubrication and Crankcase-Oil Dilution—S. W. Sparrow
29—Minneapolis Section—Pyroxylin Finishes
29—San Francisco Group—California Tests of Air-Cleaners in Volcanic Ash Districts—F. J. Annis
Chicago Section—No meeting
Cleveland Section—No meeting
Metropolitan Section—No meeting
Pennsylvania Section—No meeting
Milwaukee Section—No meeting

FEBRUARY

5—Detroit Section—Chassis Lubrication—Joseph Bijur
12—Indiana Section—Pyroxylin Automobile Finishes
17—Buffalo Section—Marine Engines—L. M. Woolson

engine and the driving system. Clutch throw-out bearings will be perfected which are self-lubricating.

Recommended Pedal and Lining Pressures

In the discussion following the paper, Mr. Wemp said that the clutch-pedal pressure should not be under 20 lb. nor over 28 lb. Lower pressures aggravate slippage. Facing pressures as high as 55 lb. per sq. in. may be used safely provided the thermal conditions are of the best. It is possible that pressures of 150 lb. per sq. in. may be employed in the future. Motorbus service dictates an allowable pressure of 27 lb. per sq. in., while from 40 to 45 lb. per sq. in. is good passenger-car practice. Mr. Wemp assumes a coefficient of friction for clutch facing of from 0.20 to 0.25 for single or two-plate designs, but from 0.12 to 0.15 should be allowed in the case of multiple-disc clutches. The coefficient of friction of clutch facing is lower than that of brake-lining due to differences in the impregnating compound.

Impregnating compounds for clutch facings must not bleed when the material is heated in service nor must they be hygroscopic. Hygroscopic materials that attract moisture have been responsible for clutches freezing up in cold weather when the moisture condensed on the facings becomes frozen.

Asked whether there is any tendency to increase the diameter or length of the clutch-hub splines, Mr. Wemp replied that the 1½-in. 10-spline shaft is coming into use. The diameter of the shaft is usually in excess of that needed to transmit the engine torque. Spline length is seldom greater than 1½ in. due to the difficulty of maintaining the straightness of longer teeth during the heat-treatment of the shaft. The diameter should be increased rather than the spline length when a lower unit-pressure is desired at the spline teeth.

Mr. Wemp's paper will be published in full in a future issue of The Journal.

MORE FLEXIBLE SPRINGS NEEDED

Speakers at Detroit-Section Riding-Quality Meeting Make This Recommendation

D. R. Swinton

What advantages of softer springs can be utilized without introducing effects on riding-quality that are a detriment was the subject considered at length at the meeting of the Detroit Section held on Dec. 4. Three papers were presented and discussed.

Leighton Dunning, Detroit branch manager of the John Warren Watson Co., presented a paper on Riding-Quality. Supplementing it, Mr. Dunning said that front springs usually are much stiffer than rear springs and that the recoil from such a stiff spring is severe. But if the period of the rear spring is approximated in the design of a front spring, this is apt to produce a car that teeters very badly. However, if the free swing of the spring is controlled by adequate shock-absorbers, very much softer springs can be used at the front of a car without danger of creating a bad pitching effect or having the periodicity of the front spring too nearly identical with that of the rear spring.

Springs

In presenting his paper on the subject of springs D. R. Swinton, of the Eaton Axle & Spring Co., Cleveland, said in part that special springs for use in stated localities would improve riding-comfort, asserting that "too many urban car-users are being shaken into kidney trouble because some dealer complains of axle chatter on a few miles of sandy road frequented by one of his best customers." But he acknowledged that such a practice would cause objections from production men.

Spring design must be influenced by compromises. The problem is in regard to what factors to favor in making compromises, and he believes we should favor good roads. He suggests that cars be driven carefully over the rough roads, that perhaps aggregate 10 per cent for an average trip, and, through usage of more suitable springs for the 90 per cent of good road, get more satisfaction and easier riding over that portion. The percentages stated apply to the entire United States for actual car-miles.

Effect of Balloon Tires

The first influence of balloon tires on spring construction was to cause front springs to be made stiffer to offset the greater tire-deflection. However, it has been determined that, on ordinary good boulevards, the balloon tire transmits a continuous and disagreeable series of short, sharp jolts that are noticeable particularly at slow speed. Whatever the explanation for this action on boulevards may be it is certain that, when the axle jolts against the spring, all the blow not absorbed by the displacement of the spring is transmitted up to the passenger. On good roads, the vertical range through which the forces are exerted is usually so limited that a long stride can be taken toward curing the trouble by radically decreasing the stiffness of the springs, particularly that of front springs, without causing serious "pitching" or "bobbing." But such flexible springs do permit "pitching" when driving over rough roads, and the problem is to eliminate pitching without destroying the good qualities of the ride over good roads.

Continuing, Mr. Swinton said further that the first thought is to increase the number of frictional surfaces in the spring itself and thus reduce the mechanical efficiency of the spring, using so-called thin-leaf springs. When steel thinner than Birmingham gage No. 4, which is 0.238 in. thick, is used to construct a spring, the product usually is termed a thin-leaf spring. By using plates as thin as 0.180 in., 12, 14 and even more leaves can be used to form the spring.

Such an increase in the frictional surface of a spring increases its capacity to dissipate energy; it becomes a two-way shock-absorber, reducing the tendency of a single blow to "strike through" and also decreasing the amount of energy imparted by the spring when it rebounds. But a price must be paid for such benefits. Static friction, or friction of rest, is greater than friction of motion; consequently, the greatest resistance occurs with slight axle-movements and the least help is given when it is most needed with a large amplitude of spring movement.

Interleaf spring-friction varies with the weather, with localities and, most particularly, with the quality of lubrication. In spite of this uncertainty, it is a means of steadying a car at high speed over a rough road and makes a compromise practicable. This is true especially when no other dissipator of energy is used. When an auxiliary device is used, frictional resistance can be dispensed with to whatever extent other means can be depended upon to supply it.

Most shock-absorbers permit, even though they do not actually require, the use of springs that are much more flexible than is usual, and in this they offer a decided advantage. However, it is important that they do not exert sufficient pull on the spring to affect the advantage of the added flexibility and also that they avoid undue pre-loading, a term meaning that the spring will transmit directly to the frame, without any cushioning, all forces less than the sum of the initial tension on the strap or lever and the force necessary to overcome the static friction between the spring-leaves. It is only the actual force exerted that a passenger feels, and not the range of movement.

Mr. Swinton remarked also that after leaf-springs have ironed out as much of the trouble as they can, cushion springs and seat upholstery that come between the passenger and the

chassis springs still afford a last chance for improvement in riding-quality which should not be overlooked.

E. W. Goodwin described a form of seat for automotive vehicles that combines the seat cushion and the back into a unit mounted independently of the car body. No relative movement exists between the cushion and the back; the seat is supported on springs and moves up or down with the passenger, in contrast with the usual arrangement whereby the seat-back is held stationary in relation to the movement of the cushion and the passenger.

SAN FRANCISCANS MEET

Noyes J. Murphy, experimental engineer with the C. L. Best Tractor Co., gave an instructive lecture on Modern Development of the Medium-Speed Diesel Engine before the San Francisco members of the Society on Dec. 18. Mr. Noyes discussed the solid-injection form of engine and described the steps in its development up to the present day.

ENGINE VIBRATION DAYTON TOPIC

C. E. Summers, of the General Motors Research Corporation staff, addressed the Dayton Section of the Society on Dec. 29, choosing as his topic Engine Vibration. The paper was accompanied with many spectacular demonstrations. Mr. Summers will present somewhat the same material in a session of the Annual Meeting of the Society in Detroit on the evening of Jan. 20.

CHASSIS AND BODY PAINTING

Detroit Section Meeting Brings Out Some Points on Chassis Finishing

H. C. Mougey

Automobile painting continues to hold the general interest of automotive engineers. Two papers were read on the subject at the Dec. 18 meeting of the Detroit Section. H. C. Mougey, of the General Motors Research Corporation, treated the matter of body painting and Arthur D. Robson, director of the Standard Varnish Works, covered the matter of chassis finishing. Mr. Mougey's paper contained practically the same material as that given in this paper before the Buffalo Section and abstracted on p. 479 of THE JOURNAL for May, 1924. The paper describes testing methods employed by the General Motors laboratory and presents the conclusions of its studies of paint failures. Mr. Robson's paper is abstracted in the following paragraphs.

Chassis finishing is assuming greater importance through the introduction of more durable body-finishes. Since the new body-finishes will last much longer, proper chassis materials must be used so that failure will not result prior to the time of necessity for complete repainting. This raises the obvious question of the suitability of lacquers for chassis work. The cost of lacquer is several times that of an excellent chassis-enamel, and as lacquers cover less square feet per gallon, their ultimate cost will be much higher. Also, the adhesion of lacquer to bare metal is not as good as the adhesion of an enamel to bare metal; therefore, lacquer requires expensive undercoat operations. It is not improbable that a suitable lacquer will be produced eventually, but Mr. Robson said that no suitable material has come to his attention.

The matter of increased production places severe burdens upon the chassis finishing departments since an increased output is usually desired without increasing the floor space or the oven capacity. By the use of a fewer number of coats the output may be easily increased. A solid covering, full-bodied chassis enamel may give good results in as little as one coat. The use of an eggshell finish simplifies this matter because it masks metal imperfections to a great extent.

Another way of securing increased production with given oven equipment is to reduce the baking time, in which case a well chosen chassis enamel is an important factor. It is well, however, to point out one of the difficulties encountered in shortening the baking time. A chassis is composed of metals ranging from sheet metal to heavy castings and the sheeting will obviously heat-up to the full temperature very rapidly. Let us take an example of a 1-hr. and a ½-hr. bake. In the 1-hr. bake the sheet-metal parts will receive a full bake, whereas the heavy castings or stampings may take 15 min. before they reach full heat and they will only be exposed for the remaining 45 min. at the high temperature. If the bake is reduced to ½-hr., the sheet-metal parts will receive full-time baking, whereas the castings will receive but 15 min., since 15 min. is required to get them up to the maximum temperature. This shows that the material must be made to suit different baking-times.

A good chassis-enamel may cover a great many more square feet per gallon, this feature increasing the speed with which it may be applied. It will reduce unit costs for materials used and also aid in increased production. The properties desired in a good chassis-enamel are: a color approaching as nearly as possible the blackness of a high-heat baking japan; the luster must be that which is required, ranging from a high luster to a dull, as the case may be; the luster must furthermore be the same over various metals and over metal surfaces primed or filled with varying undercoats; the smoothness of flow of the chassis-enamel must be such that the appearance after spraying is not "pebbly," and on upright surfaces no runs or sags must be apparent.

PRODUCTION PRECAUTIONS FOR CHASSIS PAINTING

A few factory precautions should be borne in mind. The chassis must be reasonably well cleaned since the grease that it may have accumulated during assembly is injurious to the finishing process. Cleaning may be satisfactorily accomplished with a steam hose. Baking ovens should be built to give the quickest possible heat in order that the tendency to under-bake enamel on the heavy metal parts may be minimized. It is well to place extra heating coils in the ovens so that the initial rather than the final heat will be high; if the chassis is too hot when it comes out of the oven, the enamel will be sticky or tacky, a state that is unavoidable when enamel is warm. If a conveyor oven is used, the heat should be reduced suitably before stopping the conveyor during the noon hour or at closing time, so that the parts remaining in the oven shall not get an over-bake at the maximum heat, but get a longer bake at a lower heat. No formula can be given for this; it requires intelligent supervision and practices once found satisfactory must be maintained. The chassis on emerging from the oven should be cooled by an air blower to remove the tackiness due to oven heat.

LABORATORY TESTS FOR CHASSIS-ENAMELS

The proper baking-time for an enamel may be satisfactorily determined in a laboratory or experimental room. It must be remembered that a small oven will usually give faster bakes than a production oven in which the ventilation is not so good. For oil resistance tests, a small panel finished with the enamel and dried or baked a little longer than the normal time may be used. This over-bake is recommended since a chassis will dry in the factory after leaving the oven and before it is likely to be oil spotted. The prepared plate may then be immersed in lubricating oil and maintained at a temperature of 200 deg. fahr. for 48 hr. If the surface is unaffected and the oil is not discolored, oil resistance may be said to be very good.

A gasoline resistance test may be made by immersing a similar panel in gasoline and allowing this to remain immersed at the room temperature for 48 hr. On examination

of the plate, there should be no change in the appearance of the enamel and the gasoline should not be discolored. A similar water immersion test should be made, noting any change or disintegration of the enamel surface.

Elasticity may be tested by coating a piece of thin metal with the chassis enamel, giving it three or four times the normal bake and allowing the plate to cool to 75 deg. fahr., then bending it sharply over a ⅛-in. rod. An elastic chassis-enamel should not crack or break under such a test.

CAUSE AND PREVENTION OF ACCIDENTS

Uniform Laws, Education, Signals and Penalties Hold Washington Section

GEORGE M. GRAHAM

Cooperation between motorists and pedestrians, as the only effective way of reducing the number of accidents caused by the congestion of traffic because of the constantly increasing number of automobiles, was urged by George M. Graham before the Washington Section at its monthly meeting on Dec. 15 at the Cosmos Club. Each side has its rights and each should be mindful of the rights of the other, he said. Although the rate of increase of accidents, fortunately, is not so great as is the rate of increase of automobiles, the number of automobile accidents has doubled within the last 10 years. Nearly 80 per cent of the highway accidents are due to the automobile.

When thought is given to the dearth of means of relaxation and diversion that existed before the arrival of the automobile, it is apparent that the place that the motor car has made for itself in facilitating and supplementing present-day activities will never be relinquished. Perfecting it has required great vision and great courage; if a great amount of skill and labor had not been devoted to its development, we should not now be confronted with the problems of its control.

The safeguarding of traffic is a live issue, as is evidenced by the Conference on Street and Highway Safety called by Secretary Hoover for considering some of its problems. The use of the automobile must be considered from all sides, from that of the farmer as well as from that of the city dweller. Formerly, persons were dependent on the mass transportation facilities afforded by railroads and steamships; now transportation has become individualistic. But in considering the problem neither pedestrians nor motorists can be favored. Blame cannot be charged to nor does responsibility rest upon any one group. Pedestrians have rights on the sidewalk; motorists demand the right to make use of modern means of transport. Dealers and manufacturers cannot be said to be at fault in the present situation, even though they may have instructed the drivers of the cars. By some, the blame is placed upon officials for their laxity in enforcing the provisions of the laws.

CAUSES OF ACCIDENTS

Incompetence, carelessness and recklessness are the factors that cause accidents, he continued. They are due to impulse, the same kind of motive that inspired Columbus, Magellan and other great discoverers, and that sustained the world-circumnavigating aviators.

Transportation is the youngest of the sciences. It should be in the van, but it is not. Nothing that is so essential to human progress has been so slow in developing. The same methods that were in vogue at the beginning of the Christian Era continued to be used until Fulton and Stephenson made the first break by inventing the steamboat and the locomotive. The Hoover Conference will mark another epoch.

The first effort of the Conference will be directed toward the gathering of statistics concerning the causes of accidents, for remedies cannot be applied until diagnoses have been made. Then an educational campaign will be begun. First, the community will be educated to see the importance of the problem. Organizations of all kinds will be asked to assist. The aid of newspapers, chambers of commerce and similar bodies will be solicited. Children will be impressed with the importance of caution. Children are particularly responsive, especially if they are reminded by a policeman in uniform. A large percentage of accidents, he said, is chargeable to pedestrians, and pedestrians must be educated to know that automobiles have rights. Drivers, too, must be educated. Ninety-nine per cent of the drivers, however, are good drivers; they break no laws. After 4 years a man is supposed to have sufficient experience to run a stationary engine; but 4,000,000 persons, some of whom have had little or no experience, operate automobiles.

LAWS SHOULD BE UNIFORM

Much must be done in passing uniform laws in the various States. In driving from New York City to the City of Washington a driver would break a dozen laws even though he were to comply with the traffic regulations in either of the cities named.

Uniform standards of signaling, both by hand and by lights, must be adopted. Red and green lights undoubtedly will be adopted; the green to indicate safety; the red, danger.

Grade crossings are a source of constant danger. To eliminate them entirely, as has been suggested, would involve a greater expense than that of building the railroads themselves. But provision can be made that no new crossings at grade shall be constructed. Such other things as a clear view and adequate signs can be insisted upon. The suggestion that billowy pavements should be installed on the approaches to railroad crossings is impractical, for they might cause cars to stall. The further suggestion that cars in approaching a crossing should come to a full stop is also a needless waste of time, for on some railroads only a single train is operated each day. Stopping 15,000 automobiles would impede progress. The suggestion that cars should slow down to 10 m.p.h. seems reasonable, he said. Such other questions as excessive parking or no parking, narrow roadways that increase the danger, no stopping on highways, the straightening of curves, the compulsory examination of drivers and the penalties to be inflicted for violating traffic regulations are among the subjects to be considered.

Accidents, as a rule, are not caused by new drivers, but by those who are heedless, careless or incompetent. Some men are allowed to drive who have artificial arms or legs; others are not normal mentally. Those who are found to be unqualified should have their licenses revoked. Although the taking out of insurance undoubtedly provides an equity, the Conference will probably not be in favor of compulsory insurance.

PENALTIES

The comparative value, or effect, of various penalties will receive attention, added Mr. Graham. Believing that the police department should be supported, most drivers do not mind fines of $10 or $20. The only real penalty is to send the driver to jail for the maximum sentence. The impounding of cars for violation of regulations has been effective and the suggestion of its more universal enforcement has found favor in the public prints. Automobiles have been classed as deadly weapons and can just as properly be taken away. Some criticise this penalty as being left to the discretion of the judge, but a judge can take a prisoner's life and he can also take his automobile. When the owner, however, does not drive the car, depriving him of it would work a hardship on him. An owner might also lose the use of his car for an accident for which he is not to blame.

In the program that will be adopted by the Conference will be found something that everyone can do.

Chairman A. W. S. Herrington, in opening the discussion,

said that the thought left in his mind by the speaker was that the answer lies in team-work. The saturation-point, he said, is not a function of the money with which to buy automobiles but of the road-space on which to operate them.

Supporting the demand for the proper licensing of automobile drivers, C. H. Warrington declared that under the regulations as they exist at present any one can take out a license in the name of another and without having ever driven a car.

Eighty-seven members of the Section and guests were in attendance.

BUREAU OF STANDARDS ACTIVITIES

Riding-Quality, Fuel, Engine and Brake and Other Studies Described at Buffalo

S. W. Sparrow

An extremely interesting summary of the work that has been done and is being done by the automotive powerplants section of the Bureau of Standards at Washington was given by S. W. Sparrow at the meeting of the Buffalo Section on Dec. 16. He reviewed the tests of airplane engines, brakes, radiator investigations, riding-quality studies and the fuel and lubrication research. The Bureau has accorded the Society the privilege of publishing much of this material in THE JOURNAL.

Those who have a full appreciation of the value of the research work done at the Bureau of Standards will be interested to know that this institution cost the individual taxpayer less than the price of a newspaper for the year 1924. The automotive section cost each taxpayer less than 0.1 cent! Truly this is a profitable investment.

To say that one engine or one gasoline is better than another requires some standard, that is to say, some knowledge as to what qualities are desirable and what are undesirable. Such standards may never become as definite or as permanent as the standard of length, but they are none the less valuable on that account. Research leading to the development of such standards is the chief activity of the automotive powerplants section at the city of Washington. More specifically, the scope of the section includes: the investigation of scientific and technical problems connected with the design, operation and testing of internal-combustion engines, automotive vehicles and their accessories; and the investigation of qualities and characteristics of automotive fuels and lubricants.

AIR TEMPERATURE AND BAROMETER AFFECT POWER

Reviewing the comprehensive engine tests that have been made in the altitude chamber of the Bureau of Standards, Mr. Sparrow presented the more important conclusions that have been reached. He said that the effect of altitude upon engine power can be judged roughly by saying that at 20,000 ft. the power will be about one-half that at sea-level, and at 30,000 ft. it will be about one-third that at sea-level. The indicated power of an engine varies directly with the barometric pressure. From the results of over 1600 tests at the Bureau, and of numerous tests elsewhere, it is concluded that the indicated power varies inversely with, and approximately as the square-root of, the absolute temperature of the air entering the carbureter.

The specific fuel consumption in pounds per indicated horsepower hour does not vary to any extent with the temperature, except under conditions where the completeness of vaporization or the equality of distribution is materially changed by a change in the temperature. Friction horsepower decreases with an increase in altitude, being between 70 and 75 per cent as much at 25,000 ft. as at sea-level.

Turning to the brake studies of the Bureau of Standards, Mr. Sparrow said that tests of over 300 cars taken at random had shown that about 30 per cent of them failed to stop from a speed of 20 m.p.h. within 50 ft. when the service brake was used. Employing the hand brake, 40 per cent failed to stop within 75 ft. Measurements taken of the elapsed time between the receiving of a stop signal by the driver and the actual application of the brake have shown this to be approximately ½ sec. This factor is of particular importance in studies of highway capacity.

RIDING-QUALITY RECEIVING STUDY

Some attention has been given the matter of riding-comfort at the Bureau. Some time ago, Dr. H. C. Dickinson rigged-up a vibrating platform so that both the period and the amplitude of its vibrations could be changed. He found that when the number of vibrations is over 500, an amplitude of 0.001 in. is distinctly disagreeable, even when transmitted through an ordinary automobile-seat cushion. Some tests have been made recently with the occupant of a car seated on a pneumatic cushion, the pressure within the cushion being recorded by a gage. Such a device records approximate differences in the vertical forces acting on the occupant. Thus far the tests have shown very clearly that relative discomfort cannot be gaged accurately solely by differences in the magnitude of these forces. The time during which the forces are applied must be known also. The great influence of the seat-cushion design was demonstrated by these tests.

Summarizing the conclusions of the Bureau's work on crankcase-oil dilution, Mr. Sparrow said that the rate of dilution is increased with a decrease in the fuel volatility, with a decrease in the water-jacket temperature, with a decrease in the crankcase-oil temperatures and with an increase in the fuel-air ratio. The fuel-air ratio affects the rate of carbon formation and some tests indicate that the amount formed is the minimum when the mixture giving the maximum power is employed. The temperature of the metal surface upon which the carbon is formed has a vital influence upon the rate of carbon formation. If this temperature be high enough or low enough, the amount of carbon formed will be negligible. In fact, high engine-temperatures may prove very effective in removing the accumulation of carbon in an engine cylinder.

RECENT AVIATION DEVELOPMENTS

Indiana Section Learns of Air-Service Progress and Supercharger Capability

An outline of the organization that is responsible for the activities at McCook Field and an illustrated description of them given by Major E. L. Hoffman, of Grissard Flying Field, Cincinnati, together with an address by Dr. Sanford Moss, of the General Electric Co., on the subject of airplane superchargers, formed the program of the Dec. 11 meeting of the Indiana Section. The recent rapid progress made in aviation was strikingly illustrated and development now in process was explained.

McCook Field, Dayton, Ohio, is the home of the engineering division of the Army Air-Service. About 65 Air-Service army officers and 1200 civilian engineers and mechanics are employed there. Twenty Air-Service officers conduct a school, also. The engineering division is subdivided into so-called productive and non-productive sections; airplane, powerplant, armament, equipment, material and lighter-than-air are the main sections of the former, and personnel, supply and technical data, the auxiliary sections of the latter group. Each of the main sections is then subdivided Major Hoffman gave details of the subdivisions to show the complexity of the organization, but also to show how necessary such a complex organization is.

Describing a military airplane, he said that the structure

includes the fuselage, the wings and the landing-gear; the powerplant is inclusive of the propeller, the radiator, the shutters, the oil system, the starter, the generator and the battery; the fuel system comprises main tanks and gravity tanks, valves, reserve supply, reserve pumps, gages and strainers; the armament chamber, equipped with fixed or "flexible" guns, ammunition holders, feed box, ejector chute and trigger mechanism; and the "equipment," which consists of the instruments, such as gasoline and oil pressure-gages, water thermometer, navigation instruments, altitude finder, air speedometer and the like. In addition, each machine carries parachutes and a camera.

The designer of a military airplane first locates the position of the guns and then seats the pilot in the proper relation to them. He then correlates all other components of the total load and designs the wings last. Thus, a great difference exists between military and commercial airplanes and Major Hoffman believes that it is a great exaggeration to think that commercial airplanes can be converted quickly into war airplanes. "The commercial airplane will never do as a fighter or as a bomber," he said. "It would be of very little value except as a cargo carrier."

A personally conducted trip around McCook Field via moving pictures was then undertaken by Major Hoffman, who took his interested audience with him sightseeing while he talked entertainingly of the Field's equipment. Most interesting is the armament section laboratory and the testing of the synchronizing mechanism that enables fixed airplane-guns to be fired through the propeller by keeping the trigger of the gun in time with the engine crankshaft. Another "flexible" type of airplane gun is mounted in the machine on a platform that can be rotated. A 4000-lb. round bomb, the largest yet made, and a 3-in. cannon that can be fired safely in an airplane because its recoil is absorbed, were exhibited.

Each new design of propeller is given a whirling test before it is approved for service. The whirling-test stand is equipped with an electrically driven shaft on one end of which the propeller is mounted and whirled at greater speed and with greater power than actual service will require. The two wind-tunnels, one of 8-ft. diameter and another of small diameter for testing propeller sections, enable air-speeds of 80 and of 500 m.p.h. to be produced, respectively, while simulating actual air conditions in testing models very accurately made to obtain basic data for airplane wing calculations. Small stands in the wind-tunnel hold the model while the air is rushed past it. Major Hoffman alluded to the accuracy with which airplane stability and performance can be predicted by such means.

Many phases of engine testing and development are in evidence in the powerplant laboratory. One feature of interest is the experimental work on an air-cooled Liberty engine. Here also was a new Curtis radial air-cooled engine of minimum dimensions that had been running and delivering 410 hp. at 1600 r.p.m. and can run at 1800 r.p.m. Also, two Packard engines of 500 and of 800 hp., respectively, the latter being down in weight to 1.3 lb. per hp., the lowest figure yet attained for a water-cooled engine. Other improved types of engine are in process of development.

In the "jazz hangar," so-called, varied types of airplane used by the pilots for routine practice flying are kept. In the radiator shop, a cartridge type of radiator built up of tubes and designed to permit easy repair was on view. Aluminum for gasoline-tank structure is desirable because of its light weight; to overcome the tendency to leak when welded, the aluminum sheets are nickel-plated and the seams closed with soft solder applied with a soldering-iron, but this method is still in the experimental stage.

Metal parts are made and metal fuselages assembled in another shop. Fuselages of welded steel have been treacherous because of uncertainty of strength at the welds; but the welds are now tested under conditions that approximate actual service. Cowlings, exhaust-manifolds and the like are made in the sheet-metal shop.

Propellers of varied type were shown, among them a reversible propeller, and a possibility that the coming type may be in a one-piece blade, twisted to produce the desired pitch, and a hub built up of wood and bolted through, was stated. The hangars house many types of airplane that are to be tested, a lengthy process including high-speed, low-speed, rated-climb and absolute-ceiling tests. In another large building, airplanes are assembled. One airplane there is expected to fly at from 150 to 160 m.p.h. Here also are the fabric and the "dope" shops and the sand or static testroom. A "linen amphibian" airplane, a distinct advance over former types, has a Liberty engine and is as fast as a DH-4 type, 120 m.p.h.

Radio development is under the supervision of the Signal Corps. Progress has been made in direction finding, and a successful flight to a predetermined destination while the pilot could not see the ground has been accomplished. The technical data section supervises all records and photographs.

A method known as the Z-D process is used to prevent the formation of white oxide on aluminum carbureter bowls. The wood shop has an ingenious device for testing wooden ribs. The metals branch-section is developing the use of magnesium and its alloys, a desirable metal because of its extreme lightness; many uses can be made of it if satisfactory processes can be devised for casting and working it. The photographic work is supervised by the equipment section. The K-3 automatic camera uses films, in contrast to the practice still extant in Europe of using glass photographic plates; it is mounted just aft of the gunner's bay and operated by the gunner. In some single-seat airplanes, it is operated by the pilot; he looks through the drift slide, reads his altitude and ground speed from indicators, sets the camera dial to correspond and starts the camera. It is operated by an electric battery, takes pictures at predetermined intervals and changes film automatically. A truck equipped with a developing and printing outfit meets the airplane upon its descent, and finished prints are made while the truck travels back to headquarters.

Types of instruments in use were shown, among them a recently developed engine-gage unit, three instruments in one, that Major Hoffman praised highly. Previously, he said it was not possible to fly at night or in a fog unless the pilot had some definite reference point relative to the earth; there was danger of flying upside down or going into a spin, a danger now overcome. Moving pictures of parachute leaps and films of commercial airplanes now in use in Europe were then exhibited.

The Supercharger

Describing the development of the airplane supercharger, Dr. Moss said it was the outcome of the necessity in aerial warfare for a pilot to climb higher than his enemy and to swoop down upon him. Combat work during the war reached greater and greater altitude, and the machine that could climb the highest was the machine that won the aerial battle. But speed was lost in the rarefied upper regions of the earth's atmosphere and a French engineer designed the supercharger to overcome the difficulty by maintaining approximate sea-level engine-conditions at altitude. Its development in this Country has been supervised by the General Electric Co. The apparatus consists of a blower and a compressor that compresses the rare air at great altitude to sea-level pressure. The compressor is driven by a turbine actuated by exhaust gases from the engine, which, at great altitude are discharged, not into the atmosphere, but into a sealed air-tight manifold in which sea-level pressure is maintained. At say 20,000-ft. altitude, where the atmospheric pressure is 7 lb. per sq. in., the pressure within the exhaust-manifold is 14.7 lb. per sq. in. Data for use in the development of this apparatus were obtained from tests made at the summit of Pike's Peak, Colo.

Dr. Moss said that all airplanes used in future warfare will need to be supercharged, because an airplane not having a supercharger is helpless when attacked by a supercharged machine. Ceilings attained during the war were approximately 20,000 ft. but, with a supercharger, airplanes reach 30,000-ft. altitude and it is hoped that they can be developed to reach 40,000 ft.

MULTI-WHEEL VEHICLES

Illustrations of Novel Types Entertain the Metropolitan Section

Multi-wheel vehicles, their advantages and disadvantages, as compared with the conventional four-wheel type, engaged the attention of a crowded meeting of the Metropolitan Section at the Hotel Empire, New York City, on Dec. 18. A. W. S. Herrington and A. F. Masury were the speakers and their remarks were copiously illustrated by both slides and moving pictures of trucks in action. Several others who took part in the discussion exhibited views of particular types of vehicle. Following the dinner and before proceeding with the rest of the program, an intermission was taken to allow an inspection of several vehicles lined up along the curb in front of the hotel.

Mr. Herrington compared the congested conditions in thickly populated centers to those existing in the A. E. F. during the shift from St. Mihiel to the Meuse Argonne. This movement, he said, was the largest transfer of men and materiel ever attempted in the history of the world. During this operation, 358,000 tons of road-building and repair material, moved by the Engineer Corps, served to block the normal progress of other supplies and war materiel necessary to supply the first army. In the larger cities the present result of congestion is the passing of restrictive measures and laws as to the total weight of the vehicles that shall be allowed to operate over the roads. It has been demonstrated, however, that the static loading or the weight of the vehicle is not a measure of the damage that the vehicle will do to the road. But congestion means that greater loads must be carried in order that the same amount of material or number of passengers will occupy less area.

Advantages of Multi-Wheel Trucks

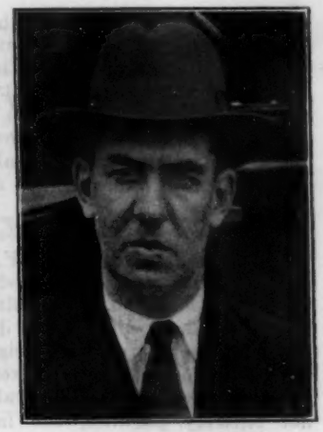
Government tests have shown that a 5-ton load can be carried as far on one set of six 38 x 9-in. pneumatic tires as on two complete sets of four. This means a saving of 25 per cent in the necessary consumption of crude rubber. Another advantage is the increased decelerating ability because of the use of brakes on the four rear wheels without the complication resulting from putting them on the front pair.

Standard Class B Army trucks, the brakes of which are in good condition, have a stopping ability equal approximately to 8 ft. per sec. per sec. when fully loaded. That of an average truck is about 6 ft. per sec. per sec. Assuming a decelerating ability of 7 ft. per sec. per sec., when a convoy of trucks is operating in a single line, as close together as is practicable while allowing sufficient space in which to stop, the mileage per hour at which the maximum number of tons can be moved over a road is 7.3. When six-wheel trucks are provided with brakes on the four rear wheels, the increased stopping-ability enables the speed to be increased from 7.3 to 16.1 m.p.h., and the amount of tonnage that can be moved increases in identically the same ratio.

The suggestion that 1½-ton trucks be made the standard for Army use, instead of 3-ton trucks, is impractical; but in six-wheel construction the ground pressure is so reduced that the pressure of the 5-ton truck per unit area is less than that of the 1½-ton truck. Consequently, heavier loads can be transported over poorer roads.

The development of the motorbus industry has given a natural impetus to multi-wheel construction, continued Mr. Herrington, because it affords better braking performance and better riding-quality. The Pacific coast, because of the road and operating conditions existing there, has made more progress than has the East, both six and eight-wheel types having been produced. In the eight-wheel type, the anticipated difficulty in steering seems to have been overcome. In the six-wheel type, in which one axle was driven and the other driving, the only difficulty occurred when slippery places were encountered. After redesigning, a much larger part of the load being carried was thrown upon the driven axle.

A. F. Masury



A. W. S. Herrington

Omission of Differential

A War Department truck that has no differential between the axles has given no trouble after running 20,000 miles. The eight-wheel truck used by the California Transit Co. has a differential between the two rear driving axles. Theoretically, a differential is necessary, but experience has shown that a chassis can be operated without it. In the Class B type trucks, some were made with and some without differentials. In the latter, the differential proper was removed and two spiders were inserted, upon which the wormwheel was mounted, and the two axles were splined into the spiders in such a way that the whole rear end was locked. The whole worm-assembly would have had to be removed before one would realize that the differential was missing. Seven years of service have developed only the usual ailments.

In the first Nash quads that were shipped to France, the front axle steered in one direction, the rear axle in the opposite direction. No differential in the center was required. Although the differentiation was satisfactory, the steering was not. So the rear axle was locked and the fact that there was no differential was overlooked; but no trouble was experienced and the practice has been continued ever since.

The English have recently developed a four-wheel-drive tractor with no differential, continued Mr. Herrington, for, as they state, if a differential were put in, one might as well not have the four-wheel drive. One of the main engineering problems to be solved is whether a differential is necessary.

Sahara Desert Experiments

In the experiments conducted by Citroen, Kegresse and Renault, in their efforts to establish routes across the Sahara desert, the Kegresse tests chiefly concerned the use of flexible belts; those of Renault were made on a six-wheel type of car driven from the two rear-wheel axles.

The nature of this construction gives an extreme amount of flexibility to any individual wheel. If one were dependent on an ordinary mechanically-operated brake, the braking problem would become difficult, for it involves a layout that runs into three planes, but recent developments in hydraulic, air and vacuum brakes have assisted materially in its solution.

The chief advantages to be derived from the use of a multi-wheel vehicle are (*a*) an increase in the pay-load carrying-capacity when compared on the basis of the number of square feet of road space occupied and (*b*) increased decelerating ability or better braking performance.

The tendency of the State Highway Commissions to set a standard of brake performance, said Mr. Herrington, will eventually find its way into commercial-vehicle fields also; the requirements for commercial vehicles should be no less than those for passenger cars. The heavier the vehicles, the greater their damage-producing ability. As the trucks become heavier, the load per square inch of braking surface

becomes greater and the shoe pressures increase, as does also the wearing of the brakes. A truck usually gets less attention and more abuse than does a passenger car, with the result that, as a general rule, the brakes of a truck are not so efficient as those of a passenger car. Increasing the braking performance will bring about an increase in the number of axles but it will also speed-up traffic and increase the number of vehicles that can be operated.

Economy of Street Space

Congestion, asserted A. F. Masury, demands the use of vehicles that will accommodate the maximum freight or passenger loads in the minimum street space. Four-wheel cars have long since been discarded by the railroads, because of the increase in weight of the freight cars and the necessity for providing greater comfort for passengers. Although the cases of the railroad and of the motorbus are not entirely parallel, the increase in the size of motor vehicles demands that the weight on the roads be distributed over as great an area as possible. Whatever the ultimate development may be, it will be attained, he believes, along the lines of six and eight-wheel vehicles. When the proposed super-highways have been built, restrictive legislation will not be allowed to limit their economic use.

R. E. Plimpton suggested several lines along which improvement is greatly to be desired. The relative ease of maneuverability of the tractor-trailer type should be considered, he said, but it does not give the same degree of body flexibility that is possible with some forms of articulated construction. They have reached a higher state of development in Europe than in this Country, a 64-passenger double-deck body being mounted on an eight-wheel chassis in England, and a 70-passenger single-decker of the six-wheel rigid type being in use in Germany. He believed that a distinct field exists for the multi-wheel vehicle but that development in this direction should not be allowed to supersede that of other more important units.

He called attention to the Latil truck, a tractor-trailer front-drive type, having a seating capacity of 29 passengers and room for 10 standing, that is used in Amsterdam, Holland. But, because of its long wheelbase, it could not be used on some routes in this Country, he said. Emergency doors are placed in accordance with police regulations, one at the rear, one at the top of the vehicle, the latter being necessary because a motorbus occasionally slides into a canal.

Eight-Wheel Trucks

In the eight-wheel truck manufactured by his company, said A. I. Marcum, the center type of steering is used with a live spindle. The spring-suspension is novel in that it is composed of three semi-elliptical springs mounted so as to give a three-point suspension. The upper spring serves as an equalizer and is fastened at either end to one of the lower springs, allowing free oscillation of the truck as it passes over obstructions. The spans of the spring are of various lengths and give varying periods of vibration in the spring-suspension. But as the suspension is triple, the load on each particular pile of the springs is relieved, and thin flexible piles can be used, which tend to produce easy riding. A 10-ton truck, having eight 36 x 8-in. pneumatic tires and equipped with air-brakes on all eight wheels, in one run covered 220 miles, carrying a load of 12 tons at an average speed of 28 m.p.h., the mileage per gallon of gasoline being 6¾.

Six-Wheelers

Describing the evolution of the six-wheel truck, E. W. Templin said that many years had elapsed since the Goodyear Company had first begun to experiment with it. In January, 1920, a completed truck had been built which has since traveled more than 96,000 miles, the only change being in the method of absorbing the torque between the two axles. The original cross-tube layout had been changed to a telescoping tubular arrangement. The cost of operation is only about two-thirds the total cost of operation of two other makes that are probably used in the greatest numbers. The third model built crossed the continent from Los Angeles to New York in 6½ days, as compared with a previous record of 13½ days. This design has recently been introduced into Detroit for use under double-deck motorbus bodies. Contracts for the tire equipment of these motorbuses are based on a tire mileage between 20,000 and 30,000.

The action of the brakes, he said, is produced by the rear ends being trunnioned at the frame and having a spring deflection that lengthens the spring so that if the brake-rods are brought to the center of the trunnion any oscillation will be handled automatically, whether for one wheel, the other, or both. If the center is also placed at a certain height, depending on the character of the spring, the rods will lengthen as the spring deflects.

The Gasoline-Electric Type

Details of construction and an outline of the advantages claimed for the Versare eight-wheel gasoline-electric-driven vehicles were presented for the first time officially by O. F. Warhus of the Versare Corporation, Albany, N. Y. These vehicles, he said, are intended only for mass transportation of either goods or passengers. As trucks, 10 tons should be the smallest capacity, and as coaches, the minimum seating-capacity should be from 40 to 44.

In understanding the experimental chassis that has been tested and perfected during the last year, the speaker asked his hearers to picture a conventional double-reduction rear-axle and a standard type of front axle set close together forming a 54-in. wheelbase, and these two axles tied together with four conventional semi-elliptic springs fastened to an 8-ft. frame. Coupled to the rear axle through a universal-joint, but suspended from and between the frame members, is a standard electric vehicle-type motor. Set between two of the cross-members of the frame is a king-pin sleeve, and mounted on the top of the frame is a roller-type fifth wheel. A duplicate of this short-wheelbase truck or bogie is set 26 ft. away and on these two bogie trucks is placed a body 35 ft. long and 8 ft. wide.

Tractor Semi-Trailer Motorcoach

A type of tractor semi-trailer motorcoach, the advantage of which lies in a better distribution of the load on the working axles than is the case when both these axles are in the rear was described by W. P. Kennedy.

In the opinion of A. M. Wolf, as a result of experiments on passenger cars, a differential between the two rear axles of a six-wheel truck is not essential, because the difference between the rotation of the two outside wheels is very small when compared with the differential motion between the wheels and the axle. The tendency toward side movement, he thinks, is more important. In a large motorbus, he found that the amount necessary for the differential to take up was about 2 to 4 in. in 45 to 50 ft.

The Paris Transportation Co., according to A. J. Slade, has met the demand for increased carrying-capacity by installing a trailer axle attached to an extended frame, the trailer axle being substantially the same as the front axle, having a steering function and being connected to the steering rods of the vehicle.

NEW SECTION SECRETARIES

Two changes have been made recently in the list of secretaries of the Sections. On account of the migration of Phil Overman from Minneapolis to Detroit, A. W. Scarratt has been appointed to carry on the secretarial duties of the Minneapolis Section. Through the transfer of P. C. Ritchie's activities to New York City area, the Chicago Section lost the services of its secretary. He has been succeeded by J. W. Tierney. The Detroit Section has been presented with a prize Section-worker in the person of Mr. Overman. May his diminutive banjo grace the program of many Detroit entertainments. Those who have occasion to write the Sections should change their records accordingly.

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

A NEW WAY TO EVALUATE DILUTION

Vacuum Distillation Transition Method of Measuring Dilution Explained

In view of the demand for an accurate and dependable method for dilution evaluation, the Cooperative Fuel Research Committee has called the matter to the attention of Committee D-2 of the American Society for Testing Materials and has suggested that the vacuum distillation transition method be given careful consideration in this connection. This method, which has been recently developed at the Bureau of Standards, is explained in the following paragraphs[1].

The dilution of the lubricating oil in the crankcase of the internal-combustion engine is a condition that has arisen in recent years. It is due largely to the necessity for utilizing fuels of lower volatility than those that were available before the demand for motor fuels began seriously to approach the limits of the available supply.

Some time ago the Bureau of Standards was called upon to make a study of the factors that control dilution, in order that information indicating means for suppressing or reducing it might be secured. The details of this work will not be discussed here. However, it soon became evident that a fairly accurate and reasonably simple and rapid method was needed for the determination of the percentage of fuel diluent in used oils. A letter was sent out to a number of oil laboratories requesting information relative to the methods employed for the measurement of dilution. About 50 replies were received, 60 per cent of which indicated atmospheric, 11 per cent vacuum and 11 per cent steam distillation methods. The remainder indicated viscosity and evaporation methods. Thus while the distillation methods were most largely used, practically no uniformity in the choice of a criterion by which to evaluate the result existed.

The rather general need for some suitable method became apparent, and it is hoped that the vacuum distillation method here described may meet this need.

Vacuum Distillation Transition Method

This method of measuring the percentage of fuel diluent in a sample of used crankcase lubricating oil is based on the fact that although we do not, in general, have an exact knowledge of the specific nature of the diluent and the oil components of the sample to be tested, we can reasonably assume that an abrupt change in the properties of the hydrocarbon compounds takes place as we proceed from the diluent to the oil.

Distillation affords a convenient method of progressively separating compounds of increasing molecular weight from the sample, and the temperature of the saturated vapor may be taken as an indication of the composition of the material that is passing the thermometer bulb at any stage of the distillation.

If a distillation is made of a charge of the used oil under the proper conditions and a curve plotted of vapor temperatures against volume of distillate, the transition from fuel diluent to oil will be indicated by a more or less abrupt rise in the vapor temperature as shown in Fig. 1.

Experiment has indicated that the point x, Fig. 1, where the curve departs to the right from a straight line a-b drawn through the straight portion of the curve in the transition region, best indicates the volume of fuel diluent in the charge. The rational basis for the choice of this point is indicated by the forms of the distillation curves for the fuel diluent and for the lubricating oil.

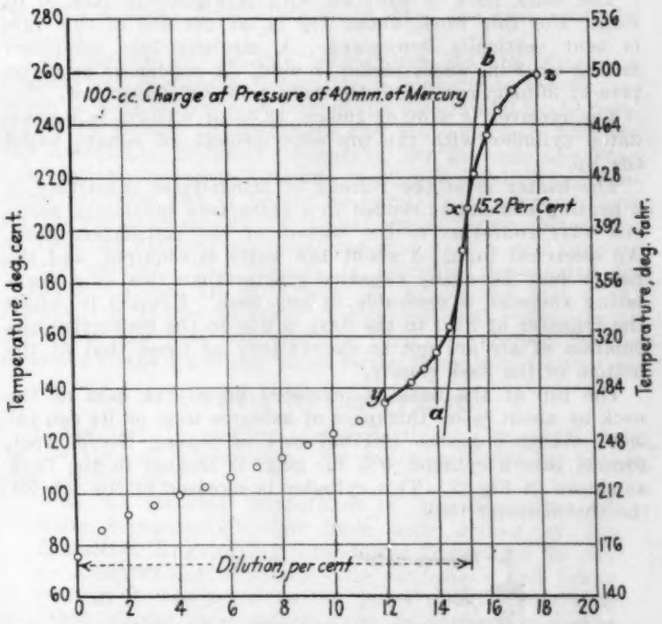


FIG. 1—DISTILLATION CURVE SHOWING METHOD OF DETERMINING PERCENTAGE OF DILUTION FROM THE CHARACTERISTICS OF THE CURVE
It Is Noted That the Transition from Fuel Diluent to Oil Is Indicated by a More or Less Abrupt Rise in Vapor Temperature

The essential conditions of distillation and the means for realizing these conditions are as follows:

(1) A constant rate of heat supply to the charge throughout the distillation. This may be secured by the use of an electric heater with constant input and an insulated distillation flask

(2) A distillation pressure low enough to preclude cracking or decomposition of the oil before the diluent is distilled off. A pressure of 4 cm. (1.57 in.) of mercury seems to be suitable for most oils. This exact pressure need not be accurately realized or controlled as a difference or a slow drift of a few millimeters during a run is not serious. The pressure may be obtained by the small gear-pumps driven by ⅛-hp. motors now available or other convenient means

(3) At least a moderate degree of fractionation of the vapor is desirable. The necessity for fractionation increases as the boiling-points of the fuel and the oil components approach each other, but it seems that fractionation secured by the use of the insulated flask with steel wool in the vapor column as described later is adequate for present needs

(4) A sufficient number of precise readings of vapor-temperatures and corresponding volumes of distillate must be taken to permit the drawing of a

[1] A paper, substantially in full, prepared by T. S. Sligh, Jr., of the Bureau of Standards, for presentation at the fifth annual meeting of the American Petroleum Institute, Fort Worth, Tex., Dec. 9 to 11, 1924.

smooth curve through the transition region. Readings should be taken for each cubic centimeter of distillate with additional readings each ½ cc. (0.031 cu. in.) in the transition region and the curve drawn to a scale sufficiently large to permit accurate location of the transition point x

Apparatus

The apparatus used at the Bureau is assembled as shown in Fig. 2. The distillation flask used is that commonly listed as a 250-cc. (15.251-cu. in.) Engler distillation flask.

The stock flask is supplied with straight-side tube, 6 in. long. For this work, about 1½ in. of the end of this tube is bent vertically downward. A straight tube condenser having an 8-in. water-jacket is used. A condenser temperature of 30 deg. cent. (86 deg. fahr.) is sufficiently low.

The receiver is a 50 or 100-cc. (3.05 or 6.10-cu. in.) graduated cylinder with the top edge ground off square below the lip.

The heater is of the Bureau of Mines type, consisting of a heating element imbedded in a refractory insulating material that conforms to the bottom of the distillation flask. An electrical input of about 150 watts is required, and the heater may have any capacity greater than this as a regulating rheostat is desirable in any case. Heaters in which the transfer of heat to the flask is due to the convective circulation of air are not so satisfactory as those that fit the bottom of the flask closely.

The top of the flask is insulated up to the base of the neck by about ½-in. thickness of asbestos wool or its equivalent. About 5 grams (0.17637 oz.) of coarse, No. 3, wool, formed into a cylinder 6½ in. long, is located in the flask as shown in Fig. 2. This cylinder is recessed at the top for the thermometer bulb.

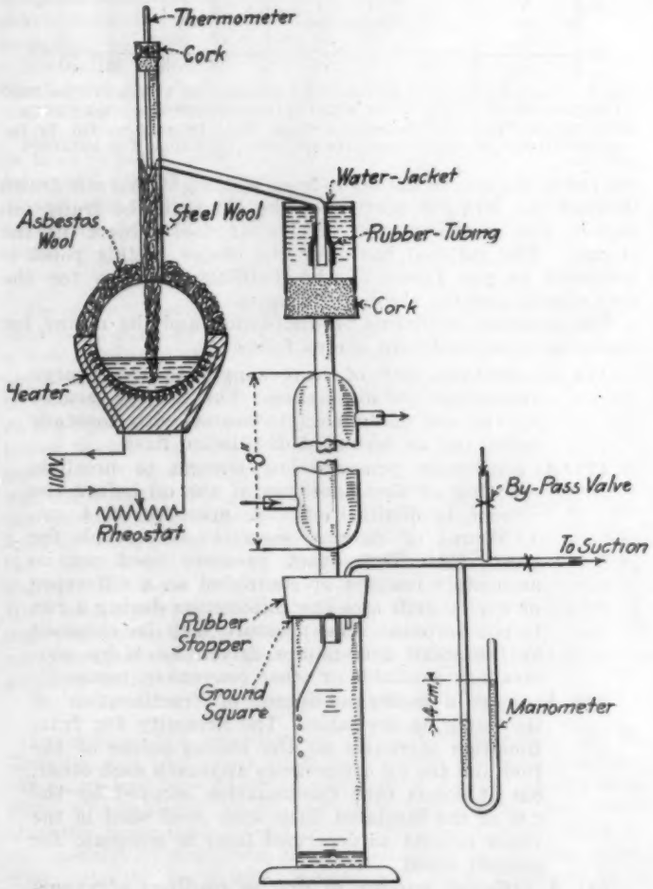


Fig. 2—Apparatus Used at the Bureau of Standards in Measuring Crankcase-Oil Dilution by the Vacuum Distillation Transition Method

An American Society for Testing Materials low-range distillation thermometer, graduated in centigrade or fahrenheit degrees, is mounted as shown in the axis of the neck of the flask with the lower edge of the white enamel backing on a level with the lower edge of the vapor tube. The bulb fits into the recess in the column of steel wool. This tends to steady the thermometer indications and prevents irregularities due to the collection of condensate on the bulb.

The thermometer is fitted in a good cork that fits into the neck of the flask. A little glycerine serves to prevent leakage, which should not be permitted at this point as the presence of air tends to depress the vapor-temperatures.

The vapor tube is joined to the condenser by a short piece of rubber tube that is surrounded by a water-jacket movable along the axis of the condenser for convenience in assembling. The tip of the vapor tube is wet with glycerine to prevent sticking to the rubber joint.

The receiver is held by the suction against the rubber stopper mounted on the condenser tip. A tube, connecting to a manometer through a bypass valve to the atmosphere and to the source of suction, also passes through the stopper.

These particular methods of securing the various joints and of controlling the pressure are suggested as being feasible with the use of ordinary laboratory materials. Other methods of reaching the same end are, of course, permissible.

Operation

The input to the heater, about 150 watts, is adjusted once for all so as to distill a 100-cc. (6.10-cu. in.) charge of water at the rate of about 2½ cc. (0.1525 cu. in.) per min. under atmospheric pressure. All runs are started with the heater hot.

A 100-cc. (6.10- cu. in.) charge of the sample is placed in the flask, the steel wool and the thermometer adjusted, the flask placed on the heater, the connections to the condenser made, the pressure in the system brought immediately to the desired value, 4 cm. (1.57 in.), and the insulation placed on the top of the flask. Care should be taken that the flask does not remain too long on the heater *before* the pressure is reduced to 4 cm. (1.57 in.), as otherwise foaming and carrying over of oil may result. An abrupt reduction in the pressure during the distillation may also result in foaming.

Readings of vapor-temperature are taken at the first drop and at each succeeding cubic centimeter of distillate until the temperature begins to rise rapidly, when readings are taken at each ½ cc. (0.031 cu. in.) or oftener if desired. These readings are continued until the distillate coming over appears to be oil and the rate of temperature rise has begun to decrease. The decrease in the differences between successive temperature readings indicates that the transition point has been passed. The time interval between the volume and temperature readings should be uniform and as short as practicable.

These observations are presented in Table 1, plotted as shown on Fig. 1 and a smooth curve drawn through the transition region y-z. A straight line a-b is drawn through the straight portion of the curve in the transition region, and the volume of distillate corresponding to the point x where the oil section of the curve begins to depart from this straight line is taken as the percentage of diluent.

The scale of plotting used in Fig. 1 has been found convenient. However, it is sometimes desirable to plot the section y-z to a larger scale to facilitate the location of point x.

It is obvious that for approximate work the per cent dilution may be evaluated directly from the data as the volume corresponding to the beginning of the decrease in rate of temperature rise. For instance, on this basis, the per cent dilution of the sample run would be taken as 15½ per cent. This approximation may, however, lead to error if the temperature readings are not taken at small volume-intervals, or if the data are erratic.

Over-points, first drop, lower than 65 deg. cent. (149 deg. fahr.) at 4-cm. (1.57-in.) pressure should be regarded with suspicion as possibly indicating appreciable air leakage into the vapor column. Used oils generally show over-points of

about 80 deg. cent. (176 deg. fahr.), except for samples resulting from abnormal conditions of engine operation. If the over-point is really below 65 deg. cent. (149 deg. fahr.), it may be necessary to reduce the condenser temperature by the use of ice to secure complete condensation.

TABLE 1—SAMPLE DATA SHEET FOR 100-CC. (6.10 CU. IN.) CHARGE DISTILLED AT A PRESSURE OF 40 MM. (1.57 IN.) OF MERCURY

Volume Cc. Drop	Cu. In.	Temperature, Deg. Cent.	Deg. Fahr.	Difference, Deg. Fahr.
		76	169	
1.0	0.061	86	187	
2.0	0.122	91	196	
3.0	0.183	95	203	
4.0	0.244	99	210	
5.0	0.305	102	216	
6.0	0.366	106	223	
7.0	0.427	110	230	
8.0	0.488	113	236	
9.0	0.549	118	245	
10.0	0.610	122	252	
11.0	0.671	127	260	
12.0	0.732	134	273	
13.0	0.793	142	286	
13.5	0.824	147	295	9
14.0	0.854	153	307	12
14.5	0.885	163	325	18
15.0	0.915	192	378	53
15.5	0.946	221	430	52
16.0	0.977	236	457	27
16.5	1.007	245	473	16
17.0	1.038	253	488	15
18.0	1.099	259	498	

Data taken on a number of lubricating oils, together with those reported by several outside laboratories that have cooperated in checking up the method, indicate that results accurate to within ½ cc. (0.031 cu. in.) may be expected. The agreement found between the results of different runs on the same sample in a single laboratory is decidedly better than this.

The diluent used in making up artificial samples corresponded to that ordinarily present in used oils. The 20-per cent residue from commercial gasoline after 80 per cent has been distilled off in an Engler distillation approximates this diluent fairly closely.

The method described has the following advantages:

(1) A knowledge of the oil or fuel used in the engine from which the used sample is drawn is not necessary

(2) No cracking or decomposition of the oil takes place during the test

(3) The time required is short, 15 min.

(4) The evaluation of the result is not influenced appreciably by personal judgment

(5) Measurements of actual vapor-temperature are not essential. The requirement is that the indicated temperatures in a given test shall be self-consistent, as we are interested in the changes in temperature during the run and not in the true temperatures

(6) The accuracy of the test is not affected by moderate changes in procedure. For instance, the rate of distillation or the pressure at which distillation is carried on may be changed by ±50 per cent of the specified values without any appreciable effect upon the results

(6) The test method is rational rather than empirical, and reliable results are obtainable over a wider range of oils and diluents than could be expected from an empirical method

(7) The accuracy is adequate for all present needs

This method is believed to be suitable for use as a standard method for the determination of the percentage of fuel diluent in used crankcase oils.

BRAKING AND SAFETY

Safety Code Sectional Committee Takes Action on Tentative Recommendations

Operating characteristics of brakes are at present attracting widespread interest in many circles of activity. The question of suitable braking effectiveness requirements is one of the most important phases under consideration. Until recently, comparatively little attention has been devoted to this subject, and the lack of authoritative data has resulted in great uncertainty as to what can reasonably be required.

The demand for reliable information led the American Engineering Standards Committee to inaugurate the formulation of a safety code on automobile brakes and brake testing. The Bureau of Standards and the American Automobile Association accepted sponsorship for the code and have been actively engaged for some months in establishing fundamental facts and in preparing tentative recommendations for the consideration of a sectional committee representative of about 20 national organizations that have a real interest in the matter. The Society is officially represented by Clarence Carson, H. M. Crane, R. E. Fielder and C. L. Sheppy. It is the function of this sectional committee to formulate the code that will in turn be referred by the sponsors to the American Engineering Standards Committee.

A Tentative Safety Code

At the Dec. 16 meeting of the Sectional Committee, held in the City of Washington, the following tentative report was considered.

> At an informal conference of representatives of those organizations that have been invited by the American Engineering Standards Committee to act as sponsors for a safety code on brakes and brake testing, it was voted as the sense of the conference "that insofar as a code relative to automobile brakes and brake testing is concerned, the Sectional Committee confine its recommendations to the performance and testing of brake equipment". It appears that the function of this committee is not primarily to decide whether or not laws requiring a certain standard of brake performance should be enacted, but to decide what brake performance it is reasonable to require in such legislation as may be enacted.
>
> It is believed that the purpose of any regulation on this subject should be to prevent the operation of cars with brakes whose effectiveness is far below the average rather than to require the average car operator to maintain his brakes at more nearly their maximum effectiveness than he does at present. No one prefers poor brakes to good ones. A decrease in brake effectiveness causes the car operator real discomfort, for he feels less safe and realizes that he should drive more slowly. It follows that brakes will be adjusted when the discomfort involved in making or having such adjustments made is less than that of operating the car with brakes in an inferior condition. To demand better brake performance than is obtained with the average car in every-day use would be an additional hardship for the car operator which would more than overbalance whatever additional safety might be attained thereby.

RECOMMENDATION FOR FOOT-BRAKES

On a dry, hard, level road free from loose material the foot-brake shall be capable of stopping the car from a speed of 20 *m.p.h. within a distance of* 50 *ft.*

In tests of approximately 400 cars selected at random, the average distance required to stop from a speed of 20 m.p.h. was 47 ft. Of these cars 365 had two-wheel brakes and for these the average stopping distance was 48.6 ft. Nearly 30 per cent of the two-wheel brake cars did not stop within 50 ft.

The tests referred to above were made in the City

of Washington, Baltimore, New York City, Philadelphia and Massachusetts. Tests in Massachusetts were conducted by the traffic authorities of that State whereas the other tests were made under the supervision of representatives of the Bureau of Standards. Since both the Massachusetts authorities and the Bureau representatives obtained their data in the same manner, namely, by decelerometers, there is every reason to believe that the results are comparable. The cars whose brakes were tested were selected in two different ways. In one instance through advertisements in the daily papers car-owners were invited to submit their cars for test. In other cases the cars of applicants for driving licenses were examined at the same time that tests of driving ability were made. Of all the cars tested 11.2 per cent were capable of stopping with the service brake from a speed of 20 m.p.h. within a distance of 20 ft., 36.0 per cent within a distance of between 30 and 40 ft., 25.0 per cent within a distance of between 40 and 50 ft. and 27.8 per cent were not capable of stopping within 50 ft.

RECOMMENDATION FOR HAND-BRAKES

On a dry, hard, level road free from loose material the hand-brake shall be capable of stopping the car from a speed of 20 m.p.h. within a distance of 75 ft.

In tests of approximately 300 cars, the average distance required to stop from a speed of 20 m.p.h. with the hand-brake alone was 73.8 ft. Approximately 40 per cent of the cars did not stop within 75 ft. Approximately 70 per cent did not stop within 50 ft.

There is little question but that criticism will be occasioned by not requiring the same stopping-distance with the hand-brake as with the foot-brake. The term "emergency brake" creates a mental picture of an emergency in which the car operator finds that his foot-brake has failed suddenly and completely and then uses the hand-brake. Not only is the utter failure of a foot-brake extremely rare, but the possibility of a car being driven any appreciable distance without that failure being discovered is extremely remote. The hand-brake's real use is in keeping the car from sliding when it is left on a grade and in supplementing the action of the foot-brake in an emergency. The above requirement should keep a car from sliding on any grade of 15 per cent or less.

TESTING METHODS AND INSTRUMENTS

It does not appear to be the function of this committee to recommend the use of any particular method of test or of any particular instrument. It is within its province to point out possible faults or merits of both methods and instruments.

The data upon which the foregoing recommendations are based were obtained with an indicating decelerometer. This instrument is of comparatively low cost, is small and convenient to use. As its name implies, it measures deceleration and, inasmuch as the deceleration does not vary to any extent with a change in the speed, it is not necessary to know the exact speed of the car when making tests with this instrument. Knowing the deceleration it is a simple matter to calculate the distance in which a car will stop from any given speed. For convenience the dial of the instrument is so graduated as to give direct readings of the distance in which the car would stop if it were travelling at a speed of 20 m.p.h. In use the instrument tends to give stopping-distances that are too small rather than too large. Errors seldom exceed 10 per cent.

Another method of test consists in mounting a revolver upon the running-board and so connecting it that it is fired by the application of the brake. Inasmuch as the revolver is in a vertical position and pointed downward, it fires its charge directly at the road surface. If shells containing red lead are used, a very distinct mark is made upon the road. The distance from this mark to the point at which the car stopped can then be measured. With this method accurate knowledge of the car speed at the instant the brakes were applied is required.

Certain State laws require brakes capable of locking the rear wheels of two-wheel brake cars. This requirement is more severe than that which has been recommended here. Obviously the method of test, however, is very simple and does not require accurate knowledge of the speed of the car. It is evident that the ability to lock wheels should not be required of a car with four-wheel brakes but rather the ability to stop in as short a distance as a two-wheel brake car with wheels locked. The operator of a car with four-wheel brakes might be required to drive his car beside one with two-wheel brakes, the drivers of both cars being instructed to apply their brakes at a given signal. If the car with the four-wheel brakes stopped in as short a distance as the car with two-wheel brakes, which were known to be adequate, it would be considered to have fulfilled requirements.

Testing cars by methods that require the operator to apply his brakes when the car reaches a certain mark on the road has not proved satisfactory because of the difficulty in applying the brakes exactly at the mark and in determining the exact speed of the car at the instant the brakes are applied. In determining the exact speed the problem is not primarily to find an accurate speedometer but to read the speedometer at the exact moment the brakes are applied. Accurate knowledge of car speed is particularly important because of the fact that the stopping-distance varies as the square of the speed.

ROAD SURFACE, SPEED AND PEDAL PRESSURE

It is believed that recommendations should be based solely upon performance on hard, dry, level roads free from loose material, and that when tests are made under other conditions the authorities making the tests should determine what changes in performance requirements should be made.

Tests need be made at but one speed. If brakes are satisfactory at one speed it is almost certain that they will be at all other speeds.

To make the recommendations complete, to each should be added the phrase "*with a pedal pressure of not more than 1 lb.*" It is a question as to whether or not the matter of pedal pressure should not be left to the administration of such laws as may be enacted embodying these recommendations. It is probable that in most cases brake tests will be made with the car driven by its usual operator or by a traffic officer. Such being the case the car will fail to stop within the required distance if the pedal pressure necessary for the satisfactory functioning of the brakes is excessive.

FACTORS THAT AFFECT STOPPING-DISTANCES

The distance in which a car can stop depends not only upon brake effectiveness but upon whether or not the clutch is engaged and whether or not the car is operating in high gear. Unquestionably the car should be operating in its normal condition, namely, high gear, at the time the brakes are applied. It is not believed, however, that the driver of a car whose brakes are being tested should be prohibited from shifting to a lower gear or employing any other expedient that he could employ in the normal operation of the car. It is the ability to stop the car within a certain distance that this code should require and not that any specific equipment should be employed for that purpose.

RECOMMENDATIONS FOR TRUCKS

Less data are available on the performance of truck brakes than of passenger-car brakes. Of 50 trucks the average stopping-distance from 20 m.p.h. with the

service brake was 60.1 ft. and of 36 trucks the average stopping-distance with the hand-brake was 90.1 ft. It is probable that a large proportion of the trucks now in operation are not capable of stopping from a speed of 20 m.p.h. within 50 ft. with the service brake or within 75 ft. with the hand-brake. The suggestion has been made that as a temporary expedient trucks which have not braking equipment that will enable them to meet requirements shall not be permitted to operate at a speed from which they cannot stop within a distance of 50 ft. There appears to be no reason why ultimately at least the same stopping-distances should not be required for trucks and passenger cars.

Committee Action

The Sectional Committee found it impossible at its first session to give adequate consideration to all the details involved in the code. The following recommendations were approved as applying to passenger cars carrying not more than seven passengers:

(1) *Recommendation for Foot-Brakes.*—On a dry, hard level road, free from loose material, the foot-brake shall be capable of stopping the car from a speed of 20 m.p.h. within a distance of 50 ft.

(2) *Recommendation for Hand-Brakes.*—On a dry, hard, level road, free from loose material, the hand-brake shall be capable of stopping the car from a speed of 20 m.p.h. within a distance of 75 ft.

The committee decided to continue its investigations with special reference to motorbuses and trucks, these investigations to include methods of making actual service tests, the effect of loading and related problems.

The committee voted to inform the Conference on Street and Highway Safety of the above action.

INVESTIGATION OF MOTOR-TRUCK IMPACT

Data Derived from Tests of Several Truck and Tire Combinations Summarized

A report covering an investigation of motor-truck impact was presented by C. A. Hogentogler at the Fourth Annual Meeting of the Highway Research Board, National Research Council. This investigation is being carried on by the Bureau of Public Roads in cooperation with The Rubber Association of America and the Society of Automotive Engineers under the direction of a committee composed of representatives of these organizations. The representatives of the Society on this cooperative committee are the members of the Highways Committee, B. B. Bachman, chairman. The objects are as follows:

(1) Determination of cushioning effect as influenced by tire design, rubber composition, road surface roughness, load, speed and truck design

(2) Determination of stresses in slabs as influenced by motor-truck wheel impacts

Procedure and Apparatus

In the measurement of the cushioning properties of tires, the part of the investigation covered in this progress report, test trucks equipped with a measuring apparatus are driven over special road sections and the impacts are computed by formula.

The three roads used for this purpose are about 500 ft. long and are described as follows:

(1) Section of rough granite block pavement having an indicated vertical variation of 90.9 in.

(2) Section of smooth concrete pavement having a vertical variation of 12.4 in.

(3) Section of smooth concrete on which are set various types and heights of obstruction

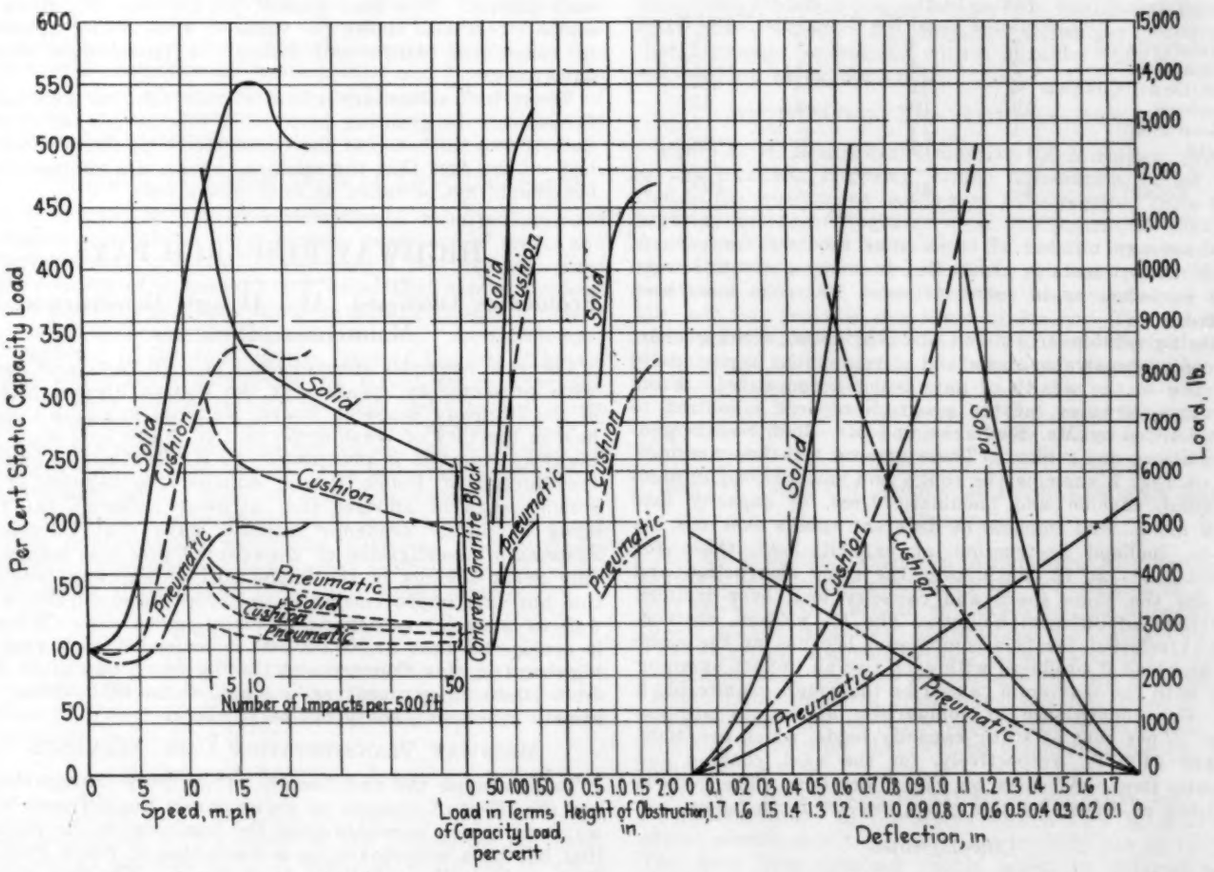


FIG. 1—CHART SHOWING ROUGH AND SMOOTH-ROAD IMPACTS WITH SOLID, CUSHION AND PNEUMATIC TIRES AT DIFFERENT SPEEDS AND LOADS AND OVER INCLINED OBSTRUCTIONS OF DIFFERENT HEIGHTS

Tests on Sections 1 and 2 disclose the number and magnitudes of impacts encountered in ordinary driving, while those on Section 3 are employed to study the detailed effects of speed, roughness, load and tire and truck design.

Accelerations are indicated by a weight supported on a spring carried in a frame that contains rolls and recording paper. The frame is attached directly to the rear wheel hub and the recording mechanism is driven by the rear wheel through a belt. Spring deflections are recorded on the same paper and simultaneously with accelerations by a system of gears and levers attached to both the truck spring and the body.

Acceleration values for various recorded weight movements were determined by a calibration in which it was shown that consistent agreement existed between accelerations computed from

(1) Accelerometer spring deflections under static loads
(2) Maximum impact forces indicated by the Kreuger apparatus
(3) Space-Time curves

The formula for computing impacts is

$$F = M\,(a - g) + s,$$

where

a = Indicated acceleration from records
F = Impact force in lb.
g = Acceleration due to gravity, 32.2 ft. per sec.
M = Mass of unsprung truck-weight
s = Truck spring-pressure at instant of impact from record

Scope of Work

This phase of the investigation contemplates static tests on 80 tires and impact tests on 105 combinations of truck and tire, and the present status is shown in Table 1.

TABLE 1—PRESENT STATUS OF TESTS

Tires	Static Tests		Impact Tests	
	Completed	Total No.	Completed	Total No.
Underinflated	2	4	4	5
Pneumatic	2	4	4	7
Cut-Down Cushion	4	19	1	25
Cushion	19	19	14	25
Worn Solid	1	17	1	17
Solid	17	17	3	26
Total	45	80	27	105

The average number of truck runs required for each of the 105 impact tests is about 40. In many cases this number is exceeded, as in some instances 100 runs have been required.

Covering certain truck and tire variables, nothing short of a comprehensive analysis and a voluminous report could do justice to the wealth of data being accumulated. From a scrutiny, however, of the progress reports submitted to the committee by Mr. Buchanan and Mr. Reid, certain general relations are evident. These general relations are indicated on Fig. 1, showing the rough and smooth-road impacts with solid, cushion and pneumatic tires, at capacity load and 12 m.p.h., and impacts at different speeds over the 1½ x 30-in. inclined obstruction at capacity-load, those for different loads at 12 m.p.h. over the same obstruction and those for the same speed and capacity load over inclined obstructions of different heights. The 1½ x 30-in. obstruction was selected for this comparison because at the same speed and load it produced with each tire an impact agreeing closely with the maximum caused by the rough granite block road. For convenience of comparison all values are expressed in per cent of static capacity loads, which are 4000, 3400 and 4400 lb., respectively, for the solid, cushion and pneumatic tires. All tires on Fig. 1 are new. The general indications as shown by this chart are set forth below.

Conclusions

Impacts from pneumatic tires on smooth roads and up to speeds of 22½ m.p.h. are practically negligible and on rough roads will probably not exceed 200 per cent of the static wheel-load. It is indicated also that this limit of impact will not be exceeded, either when the wheel drops from an obstruction of 2-in. height or when the load on the truck is increased by 50 per cent.

Impacts from a new solid tire on a very smooth road are slightly greater than those delivered by pneumatic tires on a very rough surface, being about 210 per cent of the static wheel-load for a speed of 12 m.p.h. At the same speed on a rough road the impacts from a solid tire can be as great as five times the static wheel-load. From test-runs over the obstructions it is indicated that either an increase of speed to 15 m.p.h. or a 50-per cent increase in the load will increase these impacts to about 5½ times the static wheel-load.

Impacts delivered by cushion tires range in magnitude from slightly above those of pneumatics to slightly below those of solid tires, depending upon the characteristics of the tires.

Obstruction tests indicate that impacts do not increase directly with the speed but rather that maximums are developed at certain definite speeds which are dependent upon a considerable number of variables. Tests made to date indicate a decided increase in impact when the truck speed increases from 5 to about 15 m.p.h. A slight decrease occurs from this speed to about 20 m.p.h. when a second increase is indicated which develops to the maximum at some speed beyond that at which the tests thus far have been made.

As regards the effect of road roughness on impact it may be of interest to both the maintenance and the construction engineer that even the slightest surface variations can under certain conditions greatly increase the forces delivered to the road. The concrete road used in these tests is possibly more than ordinarily smooth and on the major portion of it impacts from even the solid tire were not appreciable. The maximum of twice the static load occurred at but one point, which although not in bad condition could probably be improved and thus effect an increased safety factor against slab failure. The next highest impact was 1½ times the static. This also shows the value of a recording apparatus of some type which will locate the troublesome surface variations.

These indications are given at this time as general information. In granting permission for the release of these data it was the sense of the Committee that stress should be laid on the fact that the relations shown are representative but should not be taken as final conclusions.

HIGHWAY RESEARCH PAYS

Economics Discussed, Also Design, Construction and Maintenance Problems

Concrete examples substantiated by cold facts and figures were presented by speakers at the Fourth Annual Meeting of the Highway Research Board, National Research Council, held in the City of Washington on Dec. 4 and 5, to show that highway research is profitable. T. H. MacDonald, chief of the Bureau of Public Roads, sounded the keynote of the session when he affirmed that highway research, far from being of purely academic interest, pays heavy dividends. Systematic investigation of unanswered problems means not only great savings in the initial cost of highway construction but vast improvements in uniformity and durability, as well as material reductions in maintenance cost. When it is considered that $1,000,000,000 is expended each year on highways in this Country and that research can often save from 20 to 25 per cent on a single item, little doubt can remain concerning the profit of research.

Highway Transportation Cost Elements

To determine the cost factors of highway transportation and the effect of changes or variations in the different highway and vehicle elements upon the total cost is the problem that has been undertaken by a committee of which Prof. T. R. Agg, Iowa State College, is chairman. The first step in this investigation has been a determination of the relation

between rolling-resistance and cost of vehicle operation. In the Iowa tests on various road surfaces, the rolling-resistance has been found to vary from 20 to 700 lb. per ton of vehicle weight, whereas the gallon of gasoline is equivalent in one instance to 30 ton-miles and in another to only 3 ton-miles. It is thus obvious that tremendous savings in operating cost will result from improved highways.

Prof. W. C. McNown reported concerning the effects of different road surfaces on tire wear. This investigation, which is now in progress at the University of Kansas, includes both road-tests and tests in the laboratory where the tires are run against a smooth concrete-covered rotating drum. The degree of wear that results from runs against the drum is used as a standard of comparison for the road runs. Loss of weight of the tires is taken as the index of wear. The road runs were consistently more productive of wear than the drum runs, because of the effect of bouncing due to surface irregularities. Present tests deal with wear as it is affected by degree of inflation.

A report by Professor Wooten concerning research at North Carolina State College embraced many interesting details about rolling-resistance as it has been studied with an electrically propelled vehicle. This arrangement permits of precise measurements of the power consumption under various conditions.

Director Upham Reports

That progress in general is largely limited by the effectiveness of highway transportation was the belief of C. M. Upham, director of the Highway Research Board, who reviewed its activities. He called for greater economy in highway work, though not necessarily decreased expenditure. With the idea that a piece of research is not completed at the instant a report is written, the Board has taken steps to make the results of various projects more readily available to engineers in general by preparing for distribution, in addition to the regular full report of activities of the board, a summary bulletin that presents the important findings in very concise form. Director Upham mentioned the recent extension of the Board's organization by the formation of a committee of contact men, one from the highway commission of each State in the Union. To date, 45 of the States have appointed their representative, and the committee has already begun to function with success.

Impact and Static-Load Tests of Concrete Slabs

E. B. Smith, Bureau of Public Roads, reported on tests of concrete road-slabs under various conditions of static and impact loading. For the static tests a machine was used which consists of a special truck wheel that can be dropped upon the slab, the wheel being so arranged that different degrees of unsprung weight may be used. Accelerometers are employed in determining the force of impact. The resultant stresses are determined by strain gages appropriately mounted. Deflections of the slab under load are also taken. The static loads are applied by a hydraulic jack.

Among the conclusions thus far drawn, the following may be mentioned: the resistance of a slab to impact forces depends very largely upon the support offered by the subgrade, corner and edge resistance to impact are about equal, suitable reinforcement materially augments the resistance to impact forces, and small deformed rods closely spaced are better under impact than large rods widely spaced.

Truck Impact-Tests

C. A. Hogentogler submitted a progress report relating to the truck impact-tests that have been in progress at the Bureau of Public Roads experimental station. This report is presented in detail on p. 21.

Discussion of J. C. Sproull

J. C. Sproull, B. F. Goodrich Co., presented a very interesting discussion of the report of the Committee on Structural Design and Roads, A. T. Goldbeck, chairman, in which the reports of Messrs. Smith and Hogentogler were included. Stating that the truck tire is designed as a conserver of highway, vehicle, power and cargo, he spoke of the eagerness of the tire interests to cooperate with research agencies in bringing about the best solution of the difficult problem that confronts highway engineers, as very heavy truck traffic becomes more and more common. It was predicted that six or eight-wheel trucks may be desirable if the four-wheel vehicles are found to be too hard on the road.

Greater tire deflection means greater cushioning; thus from the cushioning standpoint alone soft tires are needed. They are, however, absorbers and not conservers of power. Smaller tire-deflections accompany the use of hard tires and their use is concomitant with smaller power consumption. The best solution of the questions relating to tire types must of necessity rest in a compromise or middle ground.

In conclusion Mr. Sproull advocated uniform traffic laws, based upon results of sound and practical research.

Highway Traffic Analysis

G. E. Hamlin, chairman of the Committee on Highway Traffic Analysis, stated that future traffic cannot be properly based upon registration figures, but will depend on many factors that must be taken into consideration in forecasting future needs.

Mr. Hamlin believed that with the exception of conditions in urban districts there will be no saturation in the utilization of motor vehicles during the present generation. It was advocated that adequate right-of-way widths be made the subject of careful consideration. Mr. Hamlin stated that, outside of urban highways, the slow-moving vehicle is one of the greatest obstacles to free, quick and safe traffic. Appropriate minimum-speed regulations should be adopted and enforced.

It was proposed that each State conduct a traffic survey as a basis for design, construction and maintenance of highways suitable for present and future needs. There are the distinctly industrial routes where heavy truck traffic prevails, whereas other routes are used by vehicles of relatively small gross weight. Mr. Hamlin's committee recommended that highways be laid out with a shoulder sufficient to permit parking along the road.

Justification For Highway Research

Prof. A. H. Blanchard, University of Michigan, president of the National Highway Traffic Association, called attention to the tremendous losses that have resulted from basing highway research programs upon opinion rather than upon facts derived from research. Professor Blanchard mentioned the tremendous value of the research on the surface treatment of gravel roads that has been carried on during the last few years in the State of Maine. The elimination of dust from gravel roads was said to have effected a saving of hundreds of thousands of dollars per year in the maintenance of motor vehicles.

Professor Blanchard advocated that each State lay aside ½ per cent of the total amount made available for highway improvement, this amount to be expended in research.

Safety Code On Automobile Brakes and Brake Testing

M. O. Eldridge, American Automobile Association, presented a brief report concerning the formulation of a safety code on automobile brakes and brake testing under the procedure of the American Engineering Standards Committee. The American Automobile Association and the Bureau of Standards have accepted sponsorship for this code and have invited representatives from numerous interested organizations and agencies to participate in the deliberations of the Sectional Committee that will be responsible for the formulation of the code.

To date, considerable experimental work has been carried on at the Bureau of Standards with a view to determining actual service conditions of brakes in daily use on the roads. The data thus obtained should assist in determining the practicable requirements for the code.

IS THE GEAR UNJUSTLY BLAMED?

Troubles Discussed That Fairly or Unfairly Are Attributed to Gears

Various phases of the gear problems were taken up in Detroit on Oct. 22 at the dinner-meeting arranged by the Research Committee during the Annual Production Meeting, and a brief report of that gathering was published in the November, 1924, issue of THE JOURNAL, p. 393. It is proposed to present here a more detailed account of the session than was possible at the time of the earlier report.

After stressing the importance of a frank interchange of ideas, Chairman Litle asked Chairman Horning of the Research Committee to relate his experience in the construction of engines. Mr. Horning stated that in his opinion faults which are oftentimes assigned to gears should in reality be laid at the door of other elements, such as crankshafts of insufficient rigidity, bad distribution, improper assembly of gears and inaccurate spacing between centers. He reported an interesting study of gear noise in which an oscilloscope revealed the fact that the crankshaft buckled considerably. It was decided that the only forces capable of causing this deflection were those that might arise from bad distribution. The installation of a suitable manifold proved this conclusion to be correct and the difficulty was at once remedied.

Lubrication of the front camshaft-bearing was said to be very important so far as noise is concerned. Force-feed lubrication was recommended for this point. Mr. Horning estimated that practically 40 per cent of the engine rejections from the test room arise from gear troubles. He called attention to the fact that engines which are continuously under load have greater durability and exhibit more satisfactory performance than is the case with engines that are intermittently loaded and that have frequent periods of idling. An example of an engine that ran 125,000 miles in truck service where load was fairly constant and continuous was cited; in this instance the bearings required absolutely no attention.

K. L. Herrmann, Studebaker Corporation of America, believed that an opportunity exists for considerable improvement in transmissions, but that there is as yet no gear that is entirely satisfactory for this service. He cited the rear-axle gear as being reasonably quiet and wondered why it is so difficult to obtain equally quiet operation for the transmission. He stated his conviction that timing-gears can be made to function as quietly as the chain. In conclusion Mr. Herrmann recommended that the gear situation be studied more carefully and that many of the problems now awaiting solution by the car manufacturers be solved by the gear-cutter and machine manufacturers instead.

Earle Buckingham, of the Pratt & Whitney Co., was asked to tell the gathering about the work of the American Society of Mechanical Engineers gear committee of which he is chairman as well as about his own experiences in producing gears. Relative to the committee work, Mr. Buckingham told about the gear-testing machine that is being built by which it is planned to study the effect of errors in the spacing or profile. Upon the completion of this machine, tests will be conducted at the Massachusetts Institute of Technology.

Speaking of his own experience in making gears, Mr. Buckingham expressed the opinion that quiet gears, metallic or non-metallic, do not exist. Defining noise as an unpleasant sound, he stressed the point that it is not quiet gears that are really desired but gears that are not noisy. He spoke interestingly of his study of the characteristic tones of various gears and the intervals between the tones as determined by the toothings and the gears, and told of his discovery that in so-called quiet transmissions all of those intervals were pure harmonics, whereas the intervals in the objectionable transmissions were bad discords. He emphasized his belief that with the harmonics properly studied, with bearings and supports sufficiently rigid and with a properly shaped case, it is possible to make transmission gears reasonably quiet so that the sound will not be noticeable but will blend in with the general hum of the engine.

Other points that were touched by Mr. Buckingham in his remarks included the direction of permissible variation in gears and errors in the strength of gears.

The importance of adequate lubrication, rigidity of mounting and proper alignment of gear-carrying members was emphasized by C. H. Sterling, of the General Motors Research Corporation. An interesting feature of Mr. Sterling's remarks was his account of studies of noise that are being made by his organization by both electrical and audition methods.

J. H. Nelson, of the Wyman-Gordon Co., classified the subjects of importance in the consideration of gears under the headings of rigidity of mountings and parts, distortion of gears, alignment and accuracy of machining. He spoke of the importance of forging gears in such a manner that the material is uniformly distributed and the grain structure is uniform throughout the entire periphery of the gear as an aid in reducing distortion in heat-treating.

Glenn Muffly, of the Lees-Bradner Co., stated that when gears which are apparently accurate produce more noise than gears that appear to be less accurate, something is wrong with the method employed for measuring the gears, or some other variable has been unwittingly introduced.

He admitted that grinding gear teeth will not in itself eliminate all sound but contended that it is the only way to maintain uniformity on hardened gears and that it does eliminate objectionable noises when the details of design and workmanship are right.

Mr. Muffly stated that a noisy gear is likely to be short-lived. In a certain instance a pair of cast-iron gears that were accurately generated proved to have greater durability than a set of hardened steel gears that were not made so accurately.

He described a transmission that was characterized by very quiet running. In this instance the case had no flat panels; it was made up of curved sections; it was comparatively large but had an intermediate wall; the shafts were large and supported by additional bearings in the middle of the case.

Greater importance was attached to the proper alignment of shafts than to center distance.

Attention was called to the necessity in any gear research to investigate but one factor at a time while other factors are kept constant. Mr. Muffly believes that much remains to be done in the way of the standardization of gear nomenclature and in popularizing the habit of thinking in terms of the really simple basic principles of the involute system instead of working backward from the complicated systems of gear-tooth proportions that have been worked out from the involute system.

He suggested that means might be devised for testing gearboxes, chassis and bodies for sympathetic vibrations. Designs of gear trains might then be checked over to see that the number of tooth contacts per second, of revolutions per second or of harmonic beats per second between various pairs of mating gears do not coincide with any vibration frequency to which the balance of the structure responds with an objectionable sympathetic vibration.

Mr. Muffly did not advance this idea as a solution for noises produced by inaccurate gears, but as a promising field for research on the gear noises that will in some cases persist even after gear-tooth errors have been reduced to a point where they are known to be a negligible factor in the production of noise.

Mr. Buckingham's experience with the noisy gear-trains that were found to have rate-of-contact ratios comparable with discordant notes in music appears to support the belief that something of value may be learned from research along this line.

W. L. Carver, of *Automotive Industries*, cited an instance which showed that quiet gears can be constructed when great care is exercised with the spacing at the pitch line. In this case no particular attention was paid to accuracy of

(*Concluded on p.* 46)

STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S. A. E. Standards Committee and other standards activities are reviewed herein

AIRCRAFT SAFETY CODE ISSUED

Sectional Committee To Act in January on Code Drafted by Subcommittees

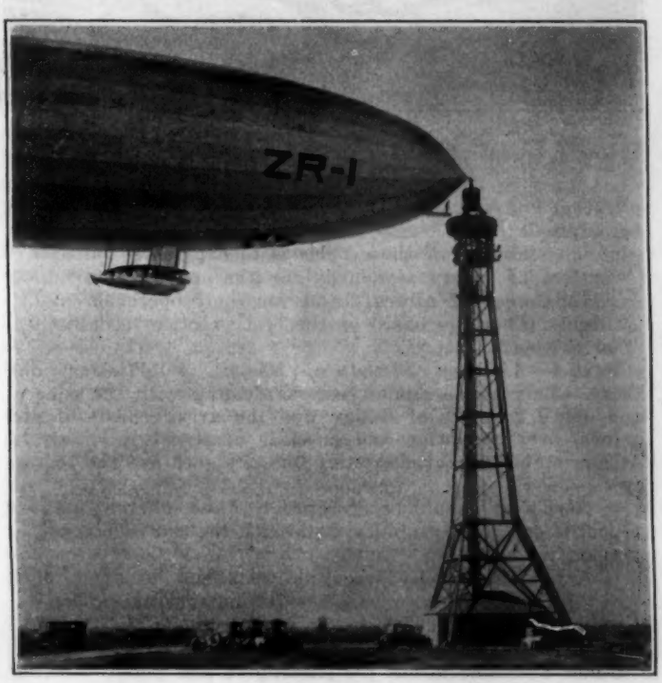
The Aeronautical Safety Code on which a Sectional Committee, sponsored by the Bureau of Standards and the Society, has been working for some years, is now in complete form and will be acted upon by the Sectional Committee at a meeting in January.

The Code has been prepared by Subcommittees, each responsible for a single part, these parts being as follows:

Introductory Part.—Scope and Nomenclature
Part 1.—Airplane Structure, Design, Fabrication and Tests
Part 2.—Powerplants, Design, Assembly and Tests
Part 3.—Equipment, Maintenance and Operation of Airplanes
Part 4.—Signals and Signaling Equipment
Part 5.—Airdromes and Airways
Part 6.—Traffic and Pilotage Rules
Part 7.—Qualifications for Airmen
Part 8.—Balloons
Part 9.—Airships
Part 10.—Parachutes

The Sectional Committee, which was formed under the rules of procedure of the American Engineering Standards Committee, was organized at a meeting held in September, 1921. H. M. Crane, representing the Society, is chairman; J. H. Ames, representing the National Advisory Committee for Aeronautics, is vice-chairman; and M. G. Lloyd, representing the Bureau of Standards, is secretary. Every important body interested in aircraft is represented on the Committee and consequently the final report may be considered as representing the consensus of opinion of the aircraft industry.

All parts of the Code as recommended by each Subdivision have been printed in pamphlet form and circularized for comment. When the final Sectional Committee Report is submitted to the Society for approval, as a sponsor body, it will be referred to the Aeronautic Division of the Standards Committee and acted upon in accordance with the usual S.A.E. Standards procedure.



THE U. S. S. SHENANDOAH AT THE LAKEHURST MOORING-MAST
All Supplies Are Carried Aboard by the Gang-Plank in the Nose of the Airship That Connects the Mast with a Passageway inside the Ship

In order that the Society members may obtain a general idea of the purpose and scope of the code, the following abstract, prepared by Arthur Halsted, assistant secretary of the Sectional Committee, is given below. Complete copies of the Code may be obtained from the Society. Comments or criticisms should be sent immediately to Dr. M. G. Lloyd, secretary of the Sectional Committee, at the Bureau of Standards, City of Washington.

Introductory Part—Scope and Nomenclature.—The introductory part includes statements concerning the scope, ap-

Copyrighted by Underwood & Underwood

RESULT OF A COLLISION BETWEEN AN ENGLISH MAIL-PLANE AND A FRENCH PASSENGER-PLANE

Copyrighted by Underwood & Underwood

ACCIDENT CAUSED BY INADEQUATE FREEDOM OF APPROACH ON A NEW LANDING FIELD

plication and waiver of the rules appearing in the Code, as, for example:

> The purpose of these rules is to express a uniform system of safety standards for the construction and maintenance of aircraft and for their operation and flight. They are based on the best practice recognized at this date.

Part 1—*Airplane Structure, Design, Fabrication and Tests.* This part includes sections dealing with the general and detail features of design and the arrangement of airplanes, fire prevention and methods of structural analysis. Among stability characteristics for airplanes are the following:

> Airplanes should be designed to have inherent statical longitudinal stability, both with the controls locked and free.
>
> Airplanes shall be directionally stable.
>
> Wind-tunnel tests of models for balance, static longitudinal stability and control shall be made on all airplanes of a radically new type.

Under accommodations for passengers and pilots, working room and clear vision for the pilot are recommended.

> Provision shall be made for safety belts or the equivalent for all passengers seated in open cockpits.
>
> In closed cabins, the seats shall be firmly fixed in place with a rest against which the feet can be braced.
>
> Every closed cabin in which passengers are carried shall be provided with at least two exits placed on different sides of the cabin, the top and bottom being counted as sides.

The following general rule is included under Materials of Construction:

> Materials used in the fabrication of an airplane shall be in accord with some recognized specification issued by a responsible organization, such as the Army, the Navy, the Forest Products Laboratory, the Society of Automotive Engineers or the American Society for Testing Materials, for specifying determinate properties.

A rule for the marking of pipes is included.

> A distinctive scheme of colors shall be used for the identification of pipes. These colored markings shall be painted on the pipes so that the identification mark of each pipe entering a connection or terminal fitting shall be easily visible when working on or inspecting that connection. It is recommended that red be used to indicate fuel pipes, yellow for oil, white for water, and blue for air.

Part 2—*Powerplants, Design, Assembly and Tests.* Part 2 includes sections on Engine Specifications, Engine Type Tests, Engine Mountings, Auxiliary Powerplant Systems and Propellers.

The following rule is included under engine starting:

> Engines of more than 200 hp. shall have means for starting, other than turning the propeller by hand, but it is recommended that starters be provided on all engines. When a hand-crank is used, either ignition retard or some back-kick device shall be used.

Engine Type Tests include a power curve determination, a durability test of 50 hr. in 5-hr. non-stop periods, an idling test and ability to pick up to load from idling, a dissembly inspection, a 15-per cent overspeed test and a flight test. For propellers, a whirling test and permissible tolerances are specified.

Part 3—*Equipment, Maintenance and Operation of Airplanes.* Part 3 includes sections treating of Equipment of Airplanes, Maintenance and Inspection of Airplanes, and the Marking of Aircraft and Logbooks.

Both a daily inspection and an inspection before flights are provided for.

All airplanes should be inspected after each day of use or after each cross-country flight and certified as to airworthiness by competent persons appointed by the owners or users of them. The inspection shall be recorded in the Aircraft Logbook.

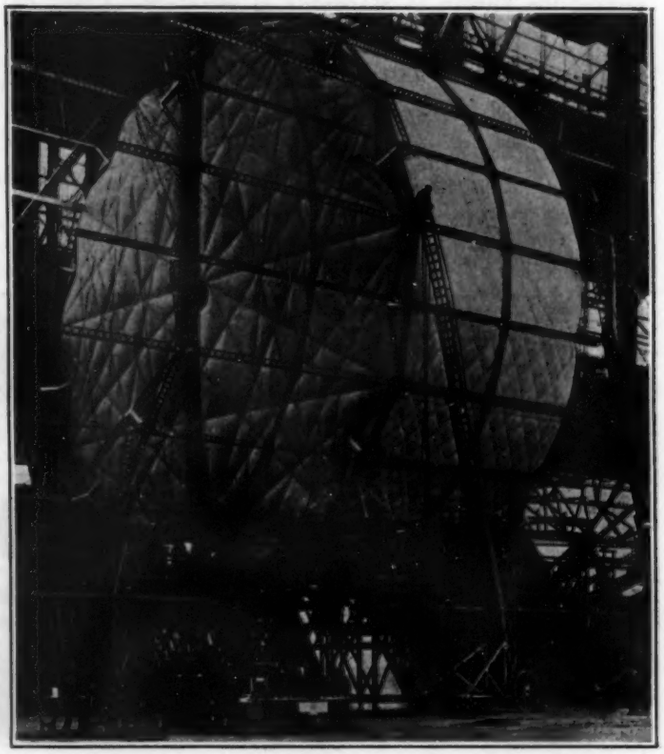
The pilot shall ascertain that the airplane is not loaded beyond its rated safe-load before commencing any flight and shall know that the airplane has been inspected and is considered to be in airworthy condition both as to its structure and engine. The pilot will be considered as certifying to this by signing the Journey Logbook.

No airplane carrying passengers should make a flight unless it has been inspected that day by a properly qualified person.

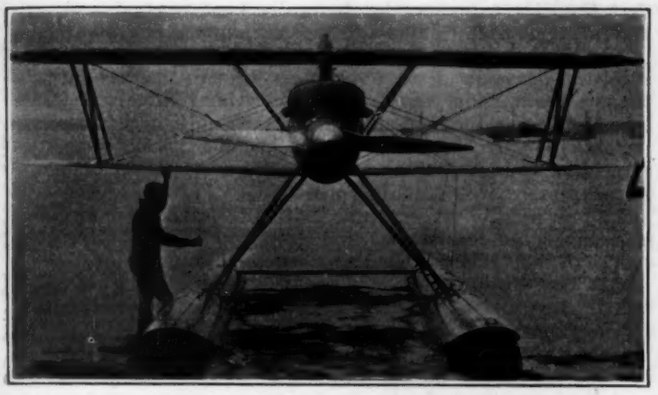
Part 4—*Signals and Signaling Equipment.* Part 4 includes sections dealing with Signaling Equipment for Airdromes, Signaling Equipment for Aircraft, Navigation Signals, Maneuver and Course Signals and Communication Signals.

The following rules are included under Landing and Wind-Direction Indication by Day:

> At every first, second and third-class airdrome, the direction of the surface wind shall be clearly indicated at all times during daylight.
>
> Every airdrome shall have a normal take-off and landing-direction to be used under conditions of no wind or breezes insufficient to affect the airplane landing. This shall be that general runway which would be most naturally used by airplanes when due consideration is given to the approaches, terrain and general conditions, both meteorologic and geographic.



ONE OF THE 20 GAS CELLS IN THE U. S. S. SHENANDOAH



THE WORLD'S FASTEST SEAPLANE
The Type of Navy-Curtiss Seaplane That Came in First and Second, Averaging 177 and 173 m.p.h., in the International Schneider Cup Race

The normal take-off and landing-direction shall be indicated at every airdrome by a combination of markers, the circular landing-area marking, a white circle as specified elsewhere to mark the landing area, and a direction line 30 ft. long to the rear of it. The combination of circle and line will point in the direction of the normal take-off and landing, with the circle in front and the line in the rear.

Instructions for landing are easily remembered if the circle symbolizes the wings of a landing airplane and the direction line its fuselage and tail.

It is necessary to have a normal landing-direction to prevent collision between airplanes using the airdrome when the general landing and take-off direction is not fixed by the wind.

Part 5—*Airdromes and Airways.*—Part 5 includes sections covering Airdromes for Landplanes—Landing-Fields; Airdromes for Seaplanes—Seaplane Stations; and Airways.

The first of the general requirements for airdromes is:

All airdromes should be registered. The airways section of the office of the Chief of Air Service, War Department, City of Washington, is the registering agency for airdromes and should receive descriptions of landing-fields and seaplane stations. This office will give information on the landing facilities in the various sections of the Country and general information and advice with reference to the organization or airdromes.

A landing-field is grade *A*, *B*, *C* or *D*, depending on its size, the quality of the landing-surface and the freedom of approach for airplanes.

An airdrome is rated 1, 2, 3, or 4, depending on its service accommodations.

A Grade-A landing-field shall have a firm runway of not less than 2500 ft. in every direction.

Airdromes will often be started with third-class equipment, and, as traffic conditions warrant, accommodations will be added until all those required for first-class airdromes are acquired.

The accommodations at an airdrome rated third-class shall be

(1) Mooring space with some tools and repair equipment conveniently near
(2) Supplies, fuel, oil, water nearby
(3) Telephone communication nearby
(4) Good roads, making the field accessible by automobile from a town
(5) Attendants available upon previous arrangement

An airway is an organized route, used by aircraft, between two or more geographical points, consisting of proper terminal airports, landing facilities en route and adequate aids to aerial navigation.

Part 6—*Traffic and Pilotage Rules.*—Part 6 includes sections establishing Rights-of-Way, Public-Safety Provisions for Aircraft Operation and Safety Measures for Operations at Airdromes.

An aircraft, when landing, taking-off, or taxying on the customary landing-areas of an airdrome, has full right-of-way over pedestrians.

On navigable water, ships have priority and freedom and this rule must be modified for seaplanes.

Seaplanes shall yield right-of-way to boats on all navigable waters, except when operating under the navigation laws for power vessels.

Every airplane maneuvering under its own power on the water shall conform to the regulations for preventing collisions at sea, and for the purpose of those regulations shall be deemed to be a power vessel.

Whenever practicable, landings shall be made at an airdrome or designated emergency landing-area. No aircraft shall be landed on highways or public parks or other public grounds or amusement-areas without permission from competent authority.

No person in any aircraft shall carry out any exhibition flying over any city or town area or populous district without permission in writing from competent authority.

No person in any aircraft shall carry out any exhibition flying over any regatta, race or meeting for public games or sports, except where especially arranged for and authorized in writing by competent authority.

No person in any aircraft shall carry out aerial acrobatics over any city or town area or populous district.

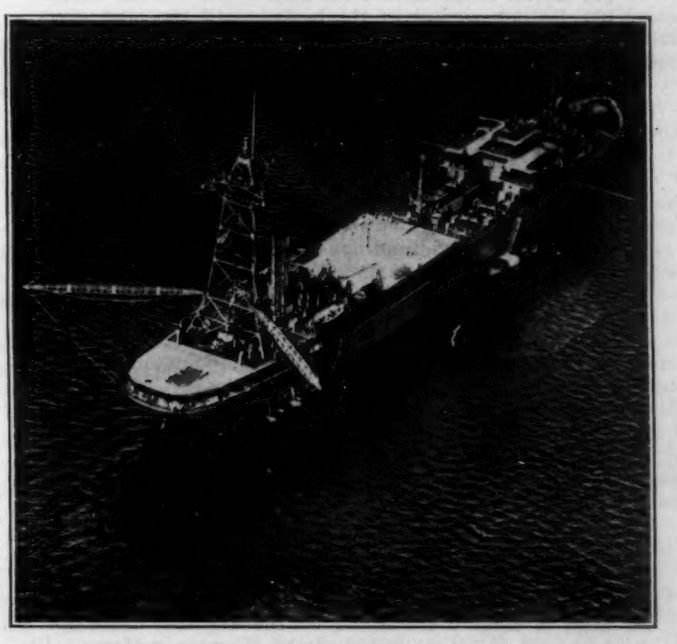
When the engine is running in an airplane, no sightseer or pedestrian, except in the discharge of duty, shall be allowed in front of the airplane or in the plane of the propeller within a distance of 75 ft.

The public or unauthorized persons shall not be permitted, either on foot or in vehicles, to go onto, or to cross the landing-area of a landing-field.

Part 7—*Qualifications for Airmen.*—Part 7 includes sections entitled Qualifications for Flying Duties and Qualifications for Ground Duties as applied to ground engineers for aircraft.

Every pilot, navigator or engineer engaged in commercial transport of passengers or cargo shall undergo a medical examination.

This examination is not intended to be excessively rigorous, but sufficient to ensure physical qualifications "compatible with the efficient performance of his duties."



THE FIRST AIRSHIP-TENDER, THE U. S. S. PATOKA
The Patoka Was Designed in Order That the Shenandoah Might Operate with the Fleet on the High Seas. The Booms on Each Side of the Mooring-Mast Are Used in Guiding the Airship when Making Fast to the Mast

AMERICA'S FASTEST AIRPLANE
The Navy-Curtiss Racer in Which Lieutenant Williams Established a Speed Record of 266.6 M.P.H.

Pilots of commercial-transport airplanes are expected to demonstrate skill and knowledge superior to pilots of private airplanes. The practical tests for commercial pilots include a "test of skill in emergency maneuvers consisting of spirals, side-slips, tail-spins and wing-over-eights."

Part 8 *Balloons (Free and Captive)*.—Part 8 includes rules for balloons under the section headings of Structural Requirements; Miscellaneous Equipment; Maintenance and Inspection; Inflation and Deflation, and Operating Rules.

Free balloons carrying passengers shall have a card or plate affixed to the inside of the basket giving the following instructions:

(1) No smoking. All matches or other lighters are to be turned over to the pilot before flight
(2) Do not throw anything overboard or pull any cords unless instructed to do so by the pilot
(3) If instructed to throw ballast, *pour* sand from the ballast bags. Do not throw out a filled bag
(4) Do not sit or stand on the edge of the basket at any time
(5) Hold on to the drag-rope side of the basket when landing
(6) Bend knees at the moment of striking the ground
(7) Stand *on* or behind the ballast bags in the basket
(8) Do not get out of the basket until the pilot gives permission
(9) If for any reason the pilot is incapacitated, to descend, pull valve rope only. Do not pull rip-cord (red tape) at a greater distance than 30 ft. from the ground

Part 9—*Airships*.—Part 9 includes rules involving airships under the section headings of Design, Equipment, Maintenance and Inspection, Inflation and Deflation, and Operating and Pilotage rules.

All rigid, semi-rigid and non-rigid airships of over 500,000-cu. ft. capacity should carry:

(1) A trail rope of not less than half the length of the ship, with a minimum of 300 ft.
(2) Guy ropes of such length as to reach not less than 125 ft. below the lowest point of the airship
(3) Eyes to which other guy-ropes can be secured
(4) Some means of hauling down the stern

When an airship is light, she appears to be nose-heavy, and, conversely, when she is heavy, she appears to be tail-heavy. This effect can be utilized at certain speeds, but at high speeds, when the effect becomes so great that the elevators cannot cope with it, the engines should be slowed-down immediately.

When a properly rigged airship, in flight, is in equilibrium, the trim is largely controlled by the distribution of air in the ballonets or by the angle of the elevator surfaces. Distribution of air in the ballonets or of gas in gas compartments, either forward or aft, is a method of static control of trim that should normally be used as much as possible, so that the elevators may be generally kept neutral and any movement of them reduced to the minimum.

Airship captains should note that rain often makes a ship tail-heavy and to appear as though it was not in proper equilibrium. Snow may sometimes affect the trim by collecting on the bow of the ship, making it nose-heavy.

Part 10—*Parachutes*.—Part 10 includes sections on Design, Tests, Installation on Aircraft and Maintenance of Parachutes.

At present the recommended practice in design for one-man parachutes, in general, is as follows:

(1) Diameter as a flat disc, not less than 24 ft.
(2) Suspension lines, not less than 16 ft.
(3) Suspension lines to have a combined strength of not less than 5000 lb.
(4) Harness and all connecting means to be at least as strong as the suspension lines to which they are attached

In regard to the installation of parachutes on aircraft, the code requires that:

Parachutes shall not limit the exit to one side only of an airplane.

The parachute, when in standby position in an aircraft, shall be ready for use. The parachute should be able to be launched with the minimum delay.

NEW JERSEY COACH REGULATIONS ISSUED

Many Suggestions Submitted by Motorcoach Committee Adopted at Trenton Hearing

At the final hearing of the New Jersey State Board of Public Utility Commissioners held in Trenton on Nov. 25, A. J. Scaife represented the Society's Motorcoach Committee. The discussion on the more important and interesting points that were raised at the hearing and the New Jersey Regulations issued by the Board on Dec. 29 as a result of the hearing are given hereinafter.

The President of the Board of Public Utility Commissioners, the Hon. H. V. Osborne, presided at the meeting. Traffic Supervisors who took part in the discussion were F. J. Daly, senior inspector of traffic; Joseph Crawford, traffic supervisor for Newark; G. W. Treacey, traffic supervisor for Jersey City; and George Chumar, traffic supervisor for the City of Elizabeth. H. A. Callan, G. H. Scragg and R. A. Hauer represented the International Motor Co.; A. C. Roy represented the Edison Lamp Works; D. B. Cartwright represented the North East Electric Co. and George H. Blake represented the Public Service Transportation Co. Many bus-owners and operators also took part in the discussion. D. C. Fenner, a member of the Society's Motorcoach Committee, officially represented the Motor Vehicle Conference Committee.

The suggestions submitted by Mr. Scaife at the hearing were based on the regulations proposed by the Motorcoach Committee as a basis for municipal regulation in general and submitted to the New Jersey Board of Public Utility Commissioners in particular. The recommendations were adopted only after joint meetings with New Jersey city-traffic supervisors and representatives of the American Electric Railway Association. The activities of the Motorcoach Committee were reviewed in full in the December issue of THE JOURNAL beginning on p. 492.

DISCUSSION AT TRENTON HEARING

COMMISSIONER H. V. OSBORNE:—The necessity for some regulation of the construction of motorcoaches seems to be apparent and is generally recognized. The tentative specifications submitted as a basis for the regulations in this State were developed by a conference committee of the supervisors of the larger cities, representatives of the larger motorcoach operators and representatives of the Board. Before adopting them a hearing must be held and the Board has, therefore, invited you gentlemen to be present today to have the benefit of your views and to hear what you have to say regarding the propriety of the adoption of any one or all of them.

A. J. SCAIFE:—It is our understanding that these specifications are to be used only for the single-deck city-type of motorcoach.

COMMISSIONER OSBORNE:—We may broaden the scope of this inquiry if it seems wise to do so, but what you say is true as regards these particular specifications.

The first is,

Body Specifications.—That a maximum overall length of body of 21 ft. and a minimum overall length of 16 ft. be adopted. That a maximum outside width of 7 ft. 10 in. and a minimum of 7 ft. be adopted. That a maximum inside height of 6 ft. 6 in. and a minimum of 6 ft. 4 in. be adopted.

Is there objection to a maximum body-length of 21 ft.?

MR. SCAIFE:—Yes. The paragraph recommended as a counter-proposition by the Motorcoach Committee of the Society of Automotive Engineers is,

The maximum overall length of body measured from the rear of the dash to the extreme rear of the body shall be 24 ft. The maximum body-width shall be 8 ft. and the minimum inside-clearance height above the floor proper, measured at the longitudinal center-line, shall be 6 ft. 2 in. Where a ramp construction is used, the minimum inside-clearance height over the ramp shall be 5 ft. 10 in.

We believe that there is no reason at this time to limit the length of a single-deck motorcoach to 21 ft., inasmuch as motorcoaches seating 29 passengers undoubtedly operate in this and in many other States.

We realize, however, that many States will desire to use these specifications and we feel that it will work a hardship on the industry to put limitations on it which will restrict further design.

COMMISSIONER OSBORNE:—It must be remembered that the purpose of these specifications is to protect and benefit the public. We are not interested particularly, although we are, of course, merely incidentally, in what the manufacturer would like to do in California or Canada or Africa. These are specifications for the motorcoaches that are to be used in the State of New Jersey and these specifications are for the protection of the people of the State of New Jersey.

MR. SCAIFE:—We would like to recommend that the maximum body length be 24 instead of 21 ft.

COMMISSIONER OSBORNE:—We would be interested in having the reasons for limiting it to 21 ft.; it may be that 24 ft. is entirely proper.

JOSEPH CRAWFORD:—The reason for a limit of 21 ft. is safety of operation within the municipalities. I might cite several instances in the City of Newark. We have to turn corners in congested sections and we find that the 24-ft. body cannot make 8 out of 10 sharp curves that we have to make within the business section; it would climb over the curb. We cannot widen our streets; we have to get along with them the best we can. We have cases where a 24-ft. motorcoach would have to cross both trolley-tracks, thereby causing delay and congesting traffic. On Park Place, Newark, where the coaches make a right-hand turn at Trinity Church, it would be impossible to handle the tremendous traffic with a 24-ft. coach, because it would have to go entirely to the opposite side of the street.

H. A. CALLAN:—It is stated that the body length should be limited because of the effect on traffic. It is my understanding that the only concern of this Board is for the safety of the traveling passengers. Is not the effect on traffic on the public highway taken care of by the Highway Law limiting the length to 28 ft.?

COMMISSIONER OSBORNE:—We will possibly consider the effect on traffic and the traveling public on the streets as well as in the coaches.

MR. CALLAN:—Then, if we are going to take the City of Newark's design of streets as affecting coach operation, it does not seem to me to be fair to limit the length of coaches operated throughout the State of New Jersey because of the defective design of streets in the City of Newark.

COMMISSIONER OSBORNE:—What is the objection to a 21-ft. limitation?

MR. CALLAN:—We might have to make the length especially for the State of New Jersey.

COMMISSIONER OSBORNE:—Of course, you recognize the fact that we cannot develop these specifications on the theory that we must have them fit 47 other States.

MR. CALLAN:—Yes, but so far we have been given to understand that the reason is the blocking of traffic. That, I think, is entirely within the jurisdiction of the Highway Department and it has already determined on 28 ft. Our experience has been that no difficulty has been met in negotiating city streets with the longer coach.

COMMISSIONER OSBORNE:—What is the longest body you have operating in the City of Newark, Mr. Crawford?

MR. CRAWFORD:—Twenty-one feet, two inches. In answer to the gentleman's statement, I have been compelled to go to Broad and Vanderpool Streets to see if I could work out a plan whereby the coaches could make the complete turn of Broad Street without blocking traffic and without going down a side street. We have had difficulty there with coaches as long as 20 ft. So far as pedestrians are concerned, we have injured in the City of Newark at least 16 people standing on the curb where a coach, in making the turn, has mounted the sidewalk.

MR. SCAIFE:—I think the determining factor in turning a corner is not so much the body length as the wheelbase and the turning-radius.

MR. BREWER:—We are now operating coaches in Camden with 23-ft. bodies and we have some rather sharp turns there. I cannot say they have any difficulty in making these turns. There seems to be plenty of room and that length of body does not seem to be too long.

But my thought is as to the interurban lines; for instance, the line between Atlantic City and Wildwood. If my recollection serves me rightly, two of those coaches measure 21 ft. 10 in. They should be about 10 in. longer to provide more room between the seats on those interurban lines.

COMMISSIONER OSBORNE:—So, you suggest a distinction between a coach in city service and one in interurban service?

MR. BREWER:—Yes, sir.

COMMISSIONER OSBORNE:—But do not all of those coaches have to come into the city and, for a considerable part of their route, run through city streets?

MR. BREWER:—Yes; that is true. Of course, in Camden we have a different condition from that in some other cities. The larger number of coaches operating in Camden make only one right-angle turn in either direction. Therefore, we would not experience the same trouble in Camden that would be experienced in Newark. Our coach operators would consider it a hardship if such a length were required to correct a condition in Newark.

MR. STEEDLE:—I would like to suggest the possibility of the Board recommending two lengths; one for congested territory and one for open country.

MR. ACETO:—I believe that the body length should not be limited because of the undeveloped stage of the motorcoach. If trolley-cars that are possibly 40 ft. long can negotiate corners, a 24-ft. or a 28-ft. coach could do likewise. As a matter of fact, one particular line in Camden with a body length of 21 ft. 4 in. turns a right-hand curve without necessitating the cutting off of a corner, but as soon as the trolleys were routed around that particular corner, the curb had to be cut off and the sidewalk narrowed. The Camden County Bus Association feels that for the present, anyway, the maximum body length should be 24 ft., and the maximum width 96 in. Inasmuch as the State law permits a vehicle 96 in. wide, we see no reason why a coach should be limited to less than that. And we feel that the maximum inside-clearance should be 6 ft. 6 in., and that a minimum inside-clearance of 6 ft. should be adopted.

G. H. SCRAGG:—I have figures here which would tend to show that the length of the coach has nothing to do with the turning-radius. Last year a Mack coach turned in a 34-ft. radius. The same coach now, but with a different wheelbase, turns in a 25 ft. 10-in. radius, which goes to show that the wheelbase governs the two turning-radii and not the length of the body.

MR. JOHNSON:—Many of the city-type coaches we are operating in Trenton and vicinity are 21 ft. 10 in. long. Some of our interurban coaches are 23 ft. long. The streets in Trenton are narrow, but we experience no difficulty.

It seems that the final determination of the length of a single-deck coach would be the length of a double-deck coach that might later be operated over the same route.

COMMISSIONER OSBORNE:—What is the situation in Jersey City with regard to the long coaches?

G. W. TREACY:—About the same as in the City of Newark; perhaps worse. We have drawn up specifications over there, and the longest we will allow is 19 ft. 10 in.

GEORGE H. BLAKE:—I am wondering what the answer will be if your Board says 21 ft. and then Jersey City says 19 ft. 10 in.

COMMISSIONER OSBORNE:—All we can do is approve or disapprove municipal permits; that is the law. If a municipality chooses to limit a coach to 19 ft., then, if the municipal permit should come to us with that limitation, we would have either to approve or disapprove it as it is. And, if another municipality places no limitation upon it, then it would be subject to our limitation. And, if a municipality places a limit of 30 ft. by way of illustration, of course, it would be subject to our modification. We would simply put our maximum on it; that would be reflected in our approval. A municipality might put any limitation it desired upon a permit to meet its purely local conditions. It might be that a certain condition in the State would come to our attention which would induce us to lift some of these restrictions. I do not say that we would do it unless it was apparent that it should be done. These are merely present regulations; they are not necessarily to be carried indefinitely into the future; they can be changed as the industry develops and conditions change.

MR. BLAKE:—Local circumstances could be met by the ordinances of the cities, but we are apt to be confronted with the situation where a line serves several municipalities.

COMMMISSIONER OSBORNE:—That is a peculiarity of the law as it is now. That condition can exist, of course, but we cannot help it.

MR. BLAKE:—Then, if the City of Newark can take care of its conditions locally and limit the size of its coaches, that should not, it seems to me, limit the size of the coaches throughout the entire State.

Here we speak of "maximum;" you might consider a leeway beyond that particular line which would meet the special conditions of the City of Newark as well as elsewhere.

MR. SCAIFE:—I might say that that is exactly what the Motorcoach Committee had in mind. We are not considering the minimum at all.

MR. BREWER:—In some cases it is economical to operate, as for feeder service that is contemplated in southern New Jersey, a smaller coach providing about 10 or 12 seats. I think the minimum of 16 ft. would work a great hardship where you find conditions of that kind.

COMMISSIONER OSBORNE:—What is the objection to eliminating the minimum?

MR. TREACY:—No objection at all. I brought up that minimum for the protection of the Jersey City men, but I do not insist upon it.

COMMISSIONER OSBORNE:—We do not want to make these specifications any more restrictive than is absolutely necessary to meet the situation.

MR. SCRAGG:—With reference to the width, 21 States have adopted the 96-in. width. If manufacturers are compelled to build a different body for each State or each part of a State, it will put them to an additional cost that has to be borne by the operator, in the first instance, and will be reflected in additional fares. The width of 96 in. is no greater than the width of a truck.

MR. SCAIFE:—The Motorcoach Committee recommends 8 ft. and the elimination of the minimum.

COMMISSIONER OSBORNE:—What is the purpose of that minimum width?

MR. CONLON:—The purpose of the minimum width is to eliminate the real small coach that would give no aisle space. The committee found that this minimum was sufficient to give at least a comfortable coach, although it is not altogether desirable.

COMMISSIONER OSBORNE:—The maximum width recommended by the conference is 7 ft. 10 in. Would there be any objection to an 8-ft. width?

MR. CRAWFORD:—I might say that we have discussed this 8-ft. maximum-width. If we could get the manufacturers to confine it to 8 ft. and not put a rain board of 2 or 3 in. on the outside, we would gladly coincide with that arrangement.

D. C. FENNER:—The State law now provides that the maximum total overall width of body shall not exceed 8 ft.

COMMISSIONER OSBORNE:—It seems to be that, if we place a limitation of 8 ft. overall on the body, the law would take care of that and meet the situation. All we can say is that the vehicle shall not exceed 8 ft. in width overall. They can make the body as wide as they please, so long as they come within that limitation. I think that practically covers that aspect of the matter.

F. J. DALY:—On the minimum inside-clearance, a vast difference of opinion seems to exist. We would like 6 ft. 4 in.

MR. TREACY:—We have coaches operating at the present time with a height of 6 ft. 4 in., but we find it is necessary to have 6 ft. 6 in. to ensure comfort.

MR. SCRAGG:—On interurban coaches cross-seats are used and no more head-room is necessary than in a private automobile, because as soon as a person steps in, he is immediately seated. This type usually operates in the country and if it is too high it will run into low-hanging branches. A man 6 ft. tall wearing a derby hat is by actual test 6 ft. 1¾ in. high. I think you are taking care of more than the majority of the people if you make the height 6 ft. 2 in.

MR. SCAIFE:—The majority of bodies now used are 6 ft. 3 in. high. That means that hundreds operating in this State today will have to be changed if you put this into force.

COMMISSIONER OSBORNE:—If we put this into effect the probabilities are we would not require present equipment in this State to be changed to conform with the new specifications. It would be only when the bodies were rebuilt that such changes would be required.

MR. SCAIFE:—The Motorcoach Committee recommends 6 ft. 2 in., measured at the center aisle, but this is to be measured to the underside of the ribs, not to the underside of the roof. As a passenger gets into a seat, he naturally slides down and, as it is desirable to have the roof arched, the height should be measured at the aisle and not at either side.

COMMISSIONER OSBORNE:—All we are interested in is seeing that the people who have to stand up can do so in reasonable comfort.

MR. TREACY:—I know from my own experience that motorcoaches run from 5 ft. 10 in. to 6 ft. 3 in. high. Six feet, four inches is not high enough; it should be 6 ft. 6 in.

COMMISSIONER OSBORNE:—Why should we quibble over an inch in height when it affects the riding-comfort of hundreds of thousands of people?

MR. SCAIFE:—Most bodies are 75 in. high; so, if this recommendation is put into effect, it will require every one to be changed.

COMMISSIONER OSBORNE:—Then they should have been changed long ago.

R. A. HAUER:—The reason the present dimensions have been developed by body-builders is that the people all over the United States want them. We change the design of our bodies every 2 or 3 months to meet changes in demand. I can say, as a manufacturer, that we can build a body with a maximum inside-clearance of 6 ft. 6 in. or any other dimension that is desired, but I doubt whether anything we agree to do would stand more than 6 months. We have never had any demand for anything like a height of 6 ft. 6 in., except from Mexico City, where people wear high hats.

MR. SCAIFE:—The only thought we had in mind is that certain municipalities will require that every passenger carried shall be seated and in that case it is not necessary to make

the roof so high. What we are asking for is just the minimum clearance. The municipalities can make it 7 ft. high if they want to.

COMMISSIONER OSBORNE:—Any comment on the following?

Window Guards.—That all buses must be equipped with window guards with at least three rails with a maximum clearance of 2 in. between them, with a minimum height of 8 in. and, if screens are used, that the minimum height of the screens shall be 8 in.

MR. SCAIFE:—I would like to read the Motorcoach Committee's report.

Suitable protection shall be provided to prevent seated passengers from inadvertently extending their arms or heads through open windows.

So long as that is provided for, we believe this requirement covers it. The majority of the new coaches today are being made with a metal sash that only drops to within 6 or 8 in. of the sill.

COMMISSIONER OSBORNE:—That is, the window itself acts as a protection.

MR. SCAIFE:—Yes, but we believe that it should be covered in a broad way.

COMMISIONER OSBORNE:—Any comment on the section relating to the partition behind the driver? This reads:

Partition Behind Driver.—That a partition be constructed of wood and glass and located behind each driver's seat and so constructed as to permit proper ventilation at the top.

MR. SCAIFE:—The Motorcoach Committee thought that that item should be omitted entirely and that the municipalities desiring partitions should specify them in their ordinances.

COMMISSIONER OSBORNE:—The objection to that suggestion is that when a coach runs through a number of municipalities, it becomes impracticable to have it handled in detail by the municipalities themselves.

MR. SCAIFE:—Personally, I do not like to see glass windows in front of seated passengers. It means that somebody's head will go through the glass when the coach comes to a sudden stop.

COMMISSIONER OSBORNE:—That is true of windshields and of all glass generally used in automobiles.

MR. SCAIFE:—In accidents where cars have stopped suddenly, passengers have been thrown against the windshield and severely hurt.

COMMISSIONER OSBORNE:—How about reinforced wire glass; would not that meet the situation?

MR. SCAIFE:—Possibly it would. We believe a curtain should be used.

COMMISSIONER OSBORNE:—A curtain will not prevent the driver from talking with passengers.

MR. SCAIFE:—A partition will not prevent that, either.

MR. CRAWFORD:—We think that a partition is most essential. Before we installed partitions, our accidents were numerous, due to the fact that the driver was continually talking to somebody sitting behind him. By installing partitions we cut down our accidents in the City of Newark 35 per cent.

MR. TREACY:—To overcome the danger of accidents in Jersey City, we placed a guard-rail to prevent anybody from being thrown against the glass.

MR. HORNER:—I have been operating coaches with heavy wire-reinforced plate-glass partitions. We have experienced no trouble at all.

MR. ACETO:—We feel that the partition should be constructed so as not to obstruct the view of the driver in using his mirror.

COMMISSIONER OSBORNE:—The next item is the emergency door. The section relating to it reads:

Emergency Door.—That all motorcoaches shall be provided with an emergency door located in the center rear. The door shall have a minimum clearance of 18 in. and extend from the floor to the upper belt-panel.

MR. SCAIFE:—The Motorcoach Committee would like to add the words "either in the left rear side or the center rear."

MR SCRAGG:—We believe that a number of objections can be raised to locating the emergency door in the center rear. A moving coach creates a vacuum and we have never been able to make a door so tight that the exhaust gas did not get into the body. As a matter of construction, we cannot build a body by cutting the back of it into three parts without creating noises and rattles that are objectionable. We are also up against the question of where we shall put the spare tire. There is no room for it on the side of the coach and with the particular type of body recommended we cannot put it on the bottom. We cannot put it on the top because of the weight of the tire and the time that a man takes to get it down. A tire of that size weighs over 300 lb. and there is no reason to believe that the passengers will help the driver with it. There is therefore no other place for the tire than in the rear of the coach. With the tire at the rear, in case of a rear-end collision it acts as a bumper and protects the passengers. Railroad companies report that in cases of accident to trains, with doors on each side of each car, the doors are never used if a train goes over on its side. The people go out the windows. Just imagine for a moment a coach going over on its side; the coach would be so out of shape that the door in the rear could not be opened; therefore nobody could use it. They would all use the windows.

The door location we recommend is at the rear of the left side. With the door there you can get in and out quicker because you have no seats obstructing it, as you do when it is placed in the rear center, and it is more easily accessible in case a fire should occur in the front of the coach. If the coach should happen to roll over, no matter where the door is, 20 or 25 people will not get out of the door very quickly; they will go to the windows. There is no law in any State requiring emergency doors. The secretary of the State of California, where coach operation is very extensive, expressed the opinion in a recent letter that the emergency door is worthless; that they had checked all the accidents they had had with coaches of all types and that they had never had a case where the rear door was used.

We are very much in favor of a door at the rear of the left side. It is absolutely not a question of cost, because the cost is borne by the operator, no matter where the door is placed.

MR. PEARTREE:—I feel that an emergency door is of more use if it is put at the left of the driver. I would suggest that, when the gas tank is in the front, the door be put at the rear of the left side, but that when the gas tank is at the extreme rear, the emergency door should be at the front on the left side. I think there is a big advantage in the door being at the left front because the driver is there and he is in a position to open the door and call the passengers. It is natural for people to go to the front of a moving vehicle, if anything does happen. If a coach should turn over, the door would be so much out of shape that it could not be opened anyway.

With the emergency door in the rear, no one has control over it; I would say that not one passenger in a thousand would know how to open the safety device if an accident should happen.

MR. JACOBUS:—On our suburban-type coaches it is absolutely necessary to carry our spare tires in the rear; it is almost impossible to put them underneath, and so far as putting them on top is concerned, that is impossible on account of the weakness of the roof.

Considerable discussion has been had about coaches turning over. I think you will find that this danger has been greatly eliminated by the modern type of coach. I believe the greatest danger is from fire and an emergency door on the rear of the left side would be the proper place for our coaches.

GEORGE CHUMAR:—I feel that the emergency door should be placed in the rear center because it is a direct exit. The passengers would not have to go to the end of the coach and then turn one way or the other.

I would like to have it specified that no seats shall be placed in the aisle in front of the rear-center emergency-door. Anything that is in the way when you have to get out in a hurry is a hindrance.

MR. TREACY:—Locating the emergency door at the rear

of the left side and eliminating the seat in front of it will increase the carrying capacity by three. Four passengers could stand where only one could be seated. We have experienced no difficulty whatsoever in putting the spare tire under the rear end of the coach.

COMMISSIONER OSBORNE:—Any comment on the provision relating to handles? This reads:

Handles.—Rails or grab-handles must be located inside the vestibule of the bus and be bolted.

MR. SCRAGG:—Instead of saying "bolted," would it not be better to say, "securely fastened"? I understand the intention of this is to prevent the use of a fastening device that would tear out. I do not think we should be limited to a single method. It is not the method that counts; it is the result. What we want is a safe handle that will be securely fastened.

COMMISSIONER OSBORNE:—We do not want to make these specifications any more technical than is absolutely necessary.

Grab-Handles for Standees.—All coaches shall be equipped with hand-rails suspended from the ceiling with sanitary fire-proof straps attached.

MR. TREACY:—The reason for providing straps is the fact that with a ceiling 6 ft. 6 in. high it is practically impossible for many people to reach the rail. They are a protection for the standees.

MR. SCAIFE:—The Motorcoach Committee desires to have this specification eliminated on account of the State's proposed regulation allowing no standees on long hauls.

COMMISSIONER OSBORNE:—It may be that we will have to differentiate between coaches that will and those that will not carry standees.

MR. SCRAGG:—Where cross-seats are used, handles are provided on them.

MR. STEEDLE:—Where cross-seats are used with handles on them, would it not be unnecessary to have straps?

MR. CRAWFORD:—We have found that if you put a handle immediately in front of the door, the passenger steps in and immediately grabs the first handle in sight, preventing the next person from coming in and having standing room. What we want to do is to encourage passengers to go to the rear of the coach as quickly as possible. That will speed-up the loading and the unloading. This can be accomplished by leaving the front seats with handles on the edges of the seats, using straps at the rear of the coach.

COMMISSIONER OSBORNE:—The heating system comes next. This section reads:

Heating System.—A suitable heating system shall be installed. The type shall be approved by the municipalities.

MR. SCRAGG:—I think that could be improved by requiring that between the months of November and May, or whichever months you wish to make it, a heating system must be provided to maintain certain temperature. If you do not do this, each municipality will specify a different device.

MR. CRAWFORD:—It is impossible to heat a motorcoach so that the air will remain at 70 deg. fahr. or some other specified temperature, because the door is continually being opened and closed. If I were to attempt to take the Public Service Railway Co. to court for violations of that regulation in the winter, I would be in court all the time.

COMMISSIONER OSBORNE:—Would it not be better to leave this matter to the Board's inspectors, rather than to the municipalities?

MR. SCAIFE:—The wording we have recommended is, "An adequate heating system shall be installed in motorcoaches when required." That puts it entirely up to the inspectors.

COMMISSIONER OSBORNE:—Any comment on the provision relating to gasoline tanks? It reads:

Gasoline Tanks.—No coach shall be operated with the gasoline tank located inside the body of the coach.

MR. SCAIFE:—The wording recommended by the Motorcoach Committee is:

When the gasoline tank is installed inside of the motorcoach body, it shall be filled and vented from the outside of the body and shall be completely enclosed inside of the body to separate it from the passenger space.

COMMISSIONER OSBORNE:—Some time ago very many of these coaches had gasoline tanks inside and it was obviously dangerous to the man who took care of them. Whether it can be done in a better way than is suggested is, of course, open for discussion.

Is there any objection to a gasoline tank inside the body, provided it is adequately separated by a fireproof partition from the interior of the body, and provided it is filled and vented from the outside of the bus?

MR. ACETO:—We believe that it makes no difference whether the gasoline tank is located inside or outside of the body, but we do believe, and from practical experience know, that the filler-cap should be located on the outside of the body and that the goose-neck running from the outside of the coach to the tank should be protected and encased on the inside of the body so as to prevent any gasoline from running on the outside of the goose-neck to become exposed in any way on the exterior of the body.

COMMISSIONER OSBORNE:—It seems to me to be perfectly obvious that a tank on the inside of a coach, not suitably separated from the body itself, is a dangerous thing, because it might be ignited by a collision, and, of course, the fire would spread over the inside of the body, so there is no use wasting time trying to discuss that obvious proposition. It should be situated so that if a collision occurred it would be properly protected. I am inclined to think that if it is underneath the coach fireproofing material should be placed between the tank and the body so that no fire contact could occur.

MR. TREACY:—From our experience, we do not think it ought to be placed inside the body, even if it is protected. We have coaches today with the gasoline tanks leaking.

COMMISSIONER OSBORNE:—It is not at all impracticable to locate tanks on the outside, is it?

MR. SCAIFE:—I would like to cite a case where the gasoline tank was on the outside of a coach, the rear wheel of which came off, but, fortunately, although the tank scraped along on the pavement so that the steel turned blue, no fire occurred. No matter where gasoline is placed we cannot be too careful about it; it is just as dangerous under the body as it is inside. I believe a recess should be built into the body and the gasoline tank put there.

COMMISSIONER OSBORNE:—The next item reads:

Wiring.—At least No. 8 stranded wire shall be used for the leads and at least No. 12 stranded wire shall be used for the distribution system. Further, all joints shall be soldered.

MR. SCAIFE:—That is a very difficult specification. Last Thursday in Cleveland all the engineers interested in this electrical feature held a meeting and after about a 2-hr. discussion on this one paragraph, this was recommended:

The minimum size of wire from the battery and generator to the point of lighting distribution shall be No. 8 A.w.g. stranded. For the interior distribution system of lights, two lamp-circuits in parallel are recommended, for which the minimum size of wire shall be No. 12 A.w.g. stranded.

The reason we put that in is that many are using bracing strips now and bolting the wires right to them.

Where more than two lamp circuits are used the minimum wire-size shall be No. 14 A.w.g. stranded or equivalent. All terminal connections shall be soldered and all splices shall be soldered and taped.

That really goes a little bit further than the Board did in the original recommendation.

COMMISSIONER OSBORNE:—Any comment on the paragraph relating to generators? It reads:

Generators.—At least a 6-volt system shall be recommended for smaller coaches and a 12-volt system for larger coaches with heavy loads. It is the opin-

(*Concluded on p.* 44)

STANDARDS COMMITTEE DIVISION REPORTS

The following Division Reports will be submitted to the Standards Committee for approval at the January Meeting

STANDARDS COMMITTEE MEETING JAN. 19

Will Be Held in Detroit on the Day Preceding Annual Meeting of the Society

Eleven recommendations will be submitted to the Standards Committee for action at the Annual Meeting, which will be held in the General Motors Building at Detroit on Monday, Jan. 19, at 2 p.m.

The recommendations to be acted upon at this meeting are printed in full in this section of THE JOURNAL in order that those interested may have sufficient time to study them prior to the Standards Committee Meeting, which will be in the nature of a public hearing. Non-members of the Standards Committee or of the Society will be welcome at the meeting and their comments on the Division recommendations will receive careful consideration.

The recommendations, as approved by the Standards Committee, will, in accordance with the Standards Committee Regulations, be submitted to a letter ballot of the voting members before becoming official S.A.E. Standards.

BAYONET-TYPE LAMP-DOOR PERMITTED

Standard Requires Use of a Non-Ferrous Metal with Metal-to-Metal Contact

At the meeting of the Lighting Division on Dec. 16 a recommendation was definitely approved for head-lamp doors and will be submitted to the Standards Committee for adoption as S.A.E. Recommended Practice. The recommendation was drawn up by the Subdivision on Head-Lamp Doors, of which B. M. Smarr, of the General Motors Corporation, is chairman, the other members being C. D. Ryder, of the Cincinnati Victor Co.; W. F. Thoms, of the Indiana Lamp Co.; H. H. Oetjen, of the Edmunds & Jones Corporation; H. M. Lucius, of the Maryland State Board of Motor Vehicle Inspection; and G. P. Doll, of the Thomas J. Corcoran Lamp Co.

The Subdivision has had this subject under consideration for many months because of the decided difference of opinion as to the desirability of recognizing the bayonet-type of head-lamp door-construction. A survey made in October indicated that 25 of the leading car manufacturers would not use the bayonet-type of construction in the future; that 6 would use it; and that 4 would use it only in an improved form. The recommendation submitted by the Subdivision at the December meeting of the Lighting Division recognized that a bayonet-type of door that locks by the application of a purely rotating force and has non-ferrous metal in contact with non-corroding material, where there is abrasive action, is satisfactory. The Division report is given herewith.

HEAD-LAMP DOORS

The head-lamp door shall be assembled to the body of the lamp in connection with the reflector by exerting a force in a direction parallel to the axis of the lamp. The force required to assemble the door shall be maintained as compression on the sealing material by a convenient locking-device, such compression to be set or released from the outside of the lamp by a mechanical device that will remain assembled with the lamp, the door or the lock-ring when the compression is released. Suitable means shall be provided in the lamp construction to prevent the lamp glass from falling out of the part to which it is assembled, when the head-lamp is opened.

These requirements are intended to exclude the use of the conventional bayonet-type of door construction. Certain forms and combinations of materials making up what is known as the rotating-type of door are easily accessible, however; but when this type of door construction is used, one of the metals at each point of metal-to-metal contact where there is an abrasive action shall be non-ferrous and the other shall be rust-proof.

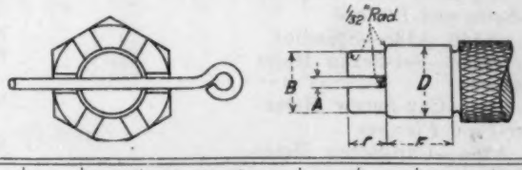
METHOD OF GAGING NUT SLOTS PROPOSED

Maximum Permissible Variation of Castle-Nut Slots and Cotter-Pin Hole

The present S.A.E. Standard for Screws, Bolts and Nuts, p. C2 of the S.A.E. HANDBOOK, does not specify the method of gaging the slots in castle nuts. This matter has recently received the consideration of the Screw-Threads Division and the accompanying recommendation, submitted by E. H. Ehrman, chairman of the Division, has been approved for adoption as S.A.E. Standard Practice.

STANDARD METHOD PROPOSED

The method of gaging castle-nut slots that is indicated in the accompanying table permits as much variation in the location of the cotter-pin hole in the screw as in the location of the cotter-pin slot in the nut. Some approximations will have to be made in the application of this method, owing to variations in the drilling and the tapping of the nut. The errors can be reduced by the nut manufacturer by making the diameter of the plug suitable for the minimum drilled-hole, and by the user by making the plug suitable for the minimum minor-diameter of the threaded hole. The diameter of the gaging pin is intended to be the mean of the width of the slot in the gage and the diameter of the cotter-pin, the drill-rod size nearest this dimension, but larger, being used. The diameter



Nut	Slot Width[1]	Cotter Pin Diameter[2]	Drill Rod		A	B	C	D[1]	E
			No.	In.					
1/4	5/64	1/16	49	0.072	0.072	0.182	1/32	0.2113	1/4
5/16	5/64	1/16	49	0.072	0.072	15/64	1/32	0.2674	19/64
3/8	1/8	3/32	34	0.110	0.110	19/64	1/16	0.3299	11/32
7/16	1/8	3/32	34	0.110	0.110	11/32	1/16	0.3834	23/64
1/2	1/8	3/32	34	0.110	0.110	13/32	1/4	0.4459	7/16

The drill rod shall preferably be tempered and should fit in the slot of the gage without shake.

[1] Minimum minor-diameter for free fit (Class 2) nuts, p. C1j of the S.A.E. HANDBOOK. If the nuts are not threaded in accordance with the American Standard for Screw Threads, the diameter shall be the same as the diameter of the go plug-gage for the bore.

[2] S.A.E. Standard dimensions, p. C2 of the S.A.E. HANDBOOK.

of the slotted part of the gage plug is made smaller so as to clear the burrs resulting from the blanking and the slotting of the nut.

SCREW-THREAD FITS RECOMMENDED

Definite Tolerances Selected for S.A.E. Standards Specifying Screw-Threads

The present S.A.E. Standards and Recommended Practices do not specify, except in isolated cases, definite screw-thread tolerances, but only the nominal diameter, the number of threads per inch and the form of thread. Following the adoption by the Society of the S. A. E. Standard for Screw-Threads, p. C1 of the S.A.E. HANDBOOK, it has been possible for the Screw-Threads Division to review the existing standards and to specify the proper class of fit for the different threads. The screw-thread fits and tolerances adopted by the Society and printed in the S.A.E. HANDBOOK were abstracted by the Screw-Threads Division from the report of the Sectional Committee on Screw-Threads that was organized by the American Society of Mechanical Engineers and the Society. The Sectional Committee report was prepared in collaboration with the National Screw-Thread Commission, on which the two Societies were represented. The complete American Standard for Screw-Threads is available in pamphlet form, it having been printed by the American Society of Mechanical Engineers.

At the meeting of the Screw-Threads Division in Detroit in October, the fits given in the accompanying list were selected for the screw-threads specified in the S.A.E. Standards. The identification symbols used are as specified in the American Standard. The basis of the system is the initial letters of the thread series, followed by the number of the class of fit. Thus, a threaded part of 1 in. diameter with 14 threads per inch and with the Free (or Class 2) Fit, would be indicated as 1 in.-14-NF-2. The letter N is used as a symbol for the American Standard because of the fact that it is used in the report of the National Screw-Thread Commission and it is desired to have all practice in this Country uniform.

SCREW-THREAD-FIT APPLICATIONS

Flywheels and Flywheel Housings	
A1 —Flywheel-Housing Flange-Holes	NC—2
A1a—Disc-Clutch Bolts	NC—2
A1b—Cone-Clutch Thread	NC—3
A1b—Tractor-Housing Bolts	NC—2
Connecting-Rod Bolts	
A5 —Body Threads	NF—3
Carbureter Flanges	
A8, A8a, A8b—Cap-Screw Holes	NC—2
Fan-Belts and Pulleys	
A14b, A14c—Spindles	NF—2
A14c—Set-Screw Holes	NC—2
Radiators	
A26—Cap-Screw Holes	NC—2
Water-Pipe Flanges	
A28a—Cap-Screw Holes	NC—2
Head-Lamps	
B1 —Fork Threaded-Ends	NF—2
B1a—Bracket Bolt and Nut	NF—2
Tail-Lamp Mounting	
B2 —Bracket Bolts	NC—2
Motorcycle Head-Lamp Mounting	
B2—Prongs	NF—2
Magneto Mountings	
B14a—Shaft-End Threads	NC—2
B14c—Cap-Screw Holes	NC—2
B14c—Timing-Lever Holes	NF—2
Generator Mounting	
B15 —Flange-Type Shaft-End	NF—2
B15a—Bracket-Type Shaft-End	NF—2
B15a—Cap-Screw Holes	NC—2
Starting-Motor Mounting	
B16b—Barrel Type	NC—2
Screws, Bolts and Nuts	
C2 —Body Threads	NF—2
High Nuts	
C4a—Threads	NF (or NC)—2
Machine-Screw Nuts	
C6 —Threads	NF (or NC)—1
Rod-Ends	
C8 —Threads	NF—2
Pressure-Gage Connections	
C45a—Threads	NF—2
Ball-and-Socket Joints	
C52—Threads	NF—2
Ball-Studs	
C58b—Shaft-End	NF—2
Tire-Pump Mounting	
E1 —Cap-Screw Holes	NC—2
Front-Axle Hubs	
F1b—Hub Bolts	NC—2
F1e—Spindle Thread	NC—3
Spring Rebound-Clips	
H3 —Bolt Threads	NC—2
Spring Center-Bolts	
H4 —Body Threads	NF—2
Central-Lever Ball-Handle Inserts	
J2 —Lever Threaded-End	NF—2
Carbureter Throttle Levers	
J3 —Rod-Ends	NF—2
Door Locks and Handles	
L1 —Door-Handle Squares	NF—2
Top-Irons	
L4 —Thread-End	NC—2

COMPRESSION-TYPE FITTINGS PROPOSED

Dimensions for 7/16-In. Tubing Added to Recommendation Submitted in June, 1924

At the Council Meeting immediately following the Standards Committee Meeting held at Spring Lake, N. J., on June 26, 1924, the Parts and Fittings Division Recommendation for Compression-Type Tube Fittings was withheld from subsequent Society action, pending an investigation with regard to the best method of publishing standards involving rights under issued letters patents.

At the meeting of the Council on Dec. 5 it was decided that the following note should be published with all standards where patents are involved:

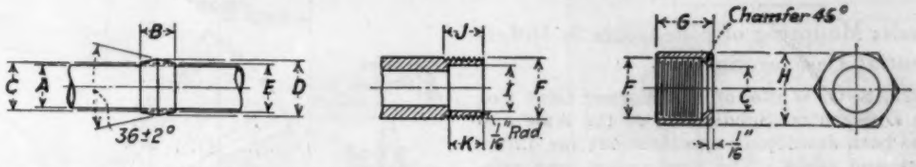
> The adoption of this standard by the Society does not insure users of constructions incorporating this standard against liability for infringement of any patents that may exist and does not constitute a recommendation of any patented or proprietary application that may be involved.

Since the June meeting of the Standards Committee, the Parts and Fittings Division has recommended the addition of the 7/16-in. size in order that the proposed series will correspond to the present S.A.E. Recommended Practice for Tube Fittings of the Flared and Soldered Types. The original recommendation, extended to include the 7/16-in. size, will therefore be presented at the Standards Committee Meeting this month for adoption as an addition to the present S.A.E. Recommended Practice for Fuel and Lubrication Tube Fittings.

The history of the consideration given to this subject by the Parts and Fittings Division was outlined in the Division Report submitted at the June, 1924, Standards Committee Meeting, and is repeated below for the information of those interested.

> Early in 1922 a Subdivision, consisting of W. H. Hollister, of the Imperial Brass Mfg. Co., who acted as chairman, and W. J. Outcalt, of the General Motors Corporation, was appointed. The first report of the Subdivision was published in June, 1923.

Proposed Dimensions for Sleeves, Nuts and Straight Threaded-Ends



Tubing Diameter *A* ±0.002	*B*	Sleeve Bore *C* ±0.002	Stock Diameter[1] *D*	Small Diameter of Taper *E*	*F*[2]	*G*	*H*	*I* ±0.002	*J* Minimum	*K*[3]
1/8	5/16	0.130	3/16	0.140	5/16–24	3/8	3/8	0.136	1/4	3/16
3/16	7/32	0.193	17/64	0.205	3/8–24	13/32	7/16	0.196	9/32	7/32
1/4	1/4	0.257	11/32	0.269	7/16–24	7/16	1/2	0.261	5/16	1/4
5/16	1/4	0.323	13/32	0.335	1/2–24	7/16	9/16	0.328	11/32	9/32
3/8	1/4	0.386	15/32	0.398	17/32–24	15/32	5/8	0.391	3/8	5/16
7/16	5/16	0.444	17/32	0.455	19/32–24	1/2	11/16	0.449	11/32	11/32
1/2	3/8	0.515	5/8	0.527	11/16–20	5/8	13/16	0.531	7/16	3/8

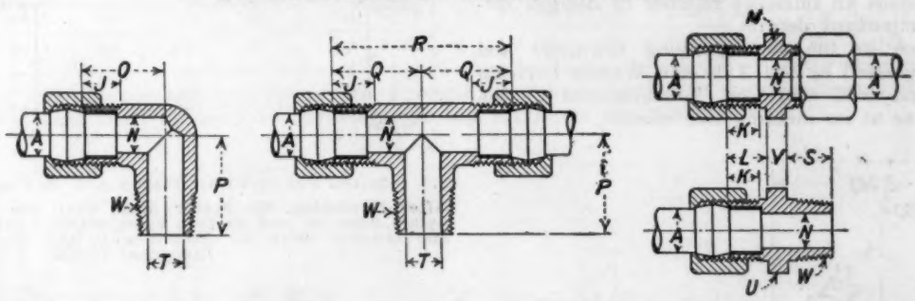
All dimensions in inches.

[1] A short flat will appear on the sleeves for the ¼, ⅜ and ⅝-in. sizes as a result of the stock diameters selected.

[2] All threads shall be in accordance with the Fine-Thread Series, Free (Class 2) Fit as given in the S.A.E. Standard for Screw-Threads.

[3] Also minimum usable length of threads on the double-end straight fitting.

Proposed Dimensions for Elbows, Tees and Unions



Tubing Diameter *A*	*L*	Diameter of Hexagon *M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	Diameter of Hexagon *U*	*V*	*W*[1]
1/8	1/4	5/16	3/32	5/8	11/16	11/16	1 3/8	3/8	3/16	7/16	5/32	1/8
3/16	9/32	3/8	1/8	5/8	11/16	11/16	1 3/8	3/8	3/16	7/16	3/16	1/8
1/4	5/16	7/16	3/16	5/8	3/4	11/16	1 3/8	3/8	3/16	7/16	3/16	1/8
5/16	11/32	1/2	1/4	5/8	3/4	11/16	1 3/8	3/8	15/64	1/2	3/16	1/8
3/8	3/8	9/16	5/16	3/4	7/8	13/16	1 5/8	7/16	5/16	9/16	7/32	1/4
7/16	13/32	5/8	11/32	27/32	1	29/32	1 13/16	7/16	5/16	5/8	7/32	1/4
1/2	7/16	11/16	13/32	15/16	1 1/8	1	2	1/2	13/32	11/16	7/32	3/8

All dimensions in inches.
[1] American Standard Pipe Thread.
Both ends of the unions shall be chamfered 45 deg. to the flats.

The type of compression fitting proposed is made by several manufacturers with slight variations in the detail dimensions. It was necessary to analyze the various dimensions used and decide upon such dimensions as would make it possible for the several manufacturers to adopt a standard without costly changes.

A special meeting was held at Detroit in October, 1923, at which the Subdivision members met with representatives of the various compression-type fitting manufacturers and reviewed the original recommendation. The dimensions agreed upon at this meeting were submitted to the members of the Division at a meeting held the same day and met with their approval. The revisions made in the original recommendation, taken individually, were of minor importance, but collectively they represented a careful refinement and correlation of corresponding dimensions for similar parts. As a result of printing the recommendations as then agreed upon, in the December, 1923, issue of THE JOURNAL, a number of criticisms were received from car and truck builders. Also, the right of several pipe-fitting manufacturers to make and market fittings in accordance with the proposed standard was questioned. Following the discussion at the special meeting, the Division's recommendation, which had been included in its report and printed in the January, 1924, issue of THE JOURNAL, was withheld in order that the industry might have an opportunity to comment on the revisions made at the meeting and to suggest any further revisions.

STANDARD DIFFERENTIALS PROPOSED

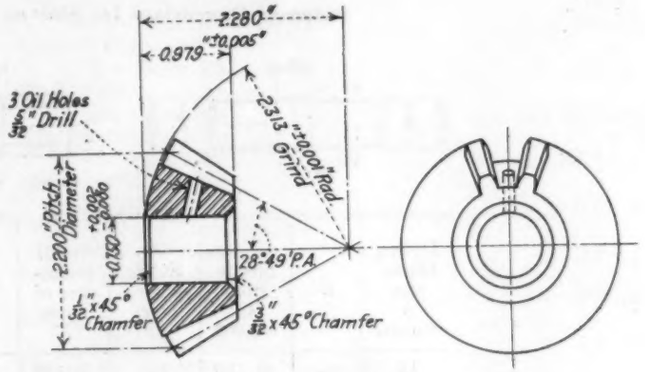
Construction Permits Mounting of Side-Gears in Differential Case or Spider

Since early in 1922, S. O. White, of the Warner Gear Co., as chairman of the Differential Subdivision of the Axle and Wheels Division, has been developing specifications for differential gears, spiders and cases. The first report was published in the January, 1923, issue of THE JOURNAL. Following comments subsequently received, the report was revised and certain dimensions unnecessary to obtain interchangeability were eliminated; the complete report being extended to permit mounting the side-gears in the case as well as in the spider.

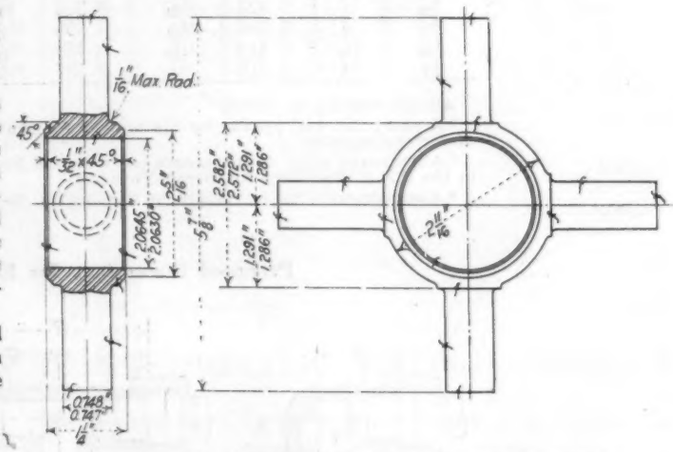
The revised report was again printed in the January, 1924, issue of THE JOURNAL in order that the members of the Society might analyze it and submit further revisions or additions that would make the proposed standard of more value to the industry. Since the publication of the revised report, the Subdivision has included a one-piece differential case of the two-pinion type.

During the preparation of this report the Subdivision has worked in collaboration with the Differential-Gear Committee of the American Gear Manufacturers Association, Mr. White being chairman of both committees. As the recommendation represents to a large extent a natural crystallization of practice, the existence of the designs proposed as recommended practice in the S.A.E. HANDBOOK will greatly simplify the problems of the different differential manufacturers who are now obliged to produce an immense number of designs differing only in unimportant details.

The report, given in the accompanying drawings and tables, has been approved by the Axle and Wheels Division by letter ballot and will, therefore, be submitted to the Standards Committee at its meeting this month.

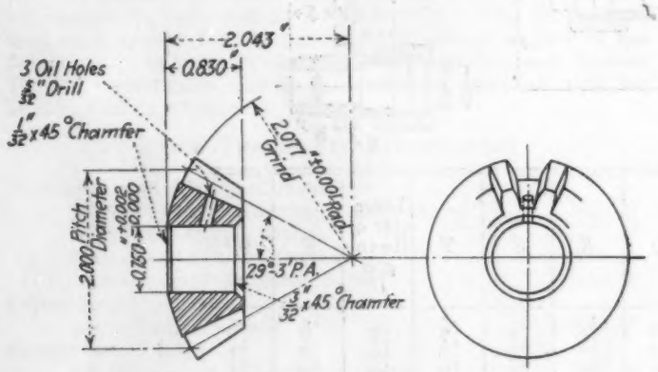


ELEVEN-TOOTH PINION FOR 20-TOOTH SIDE-GEAR

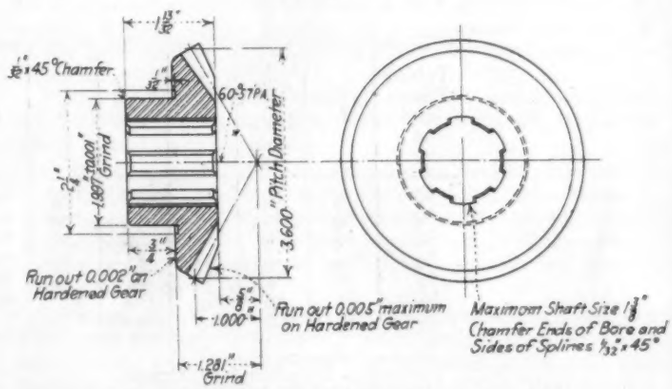


SPIDER FOR 11-TOOTH PINION AND 20-TOOTH SIDE-GEAR

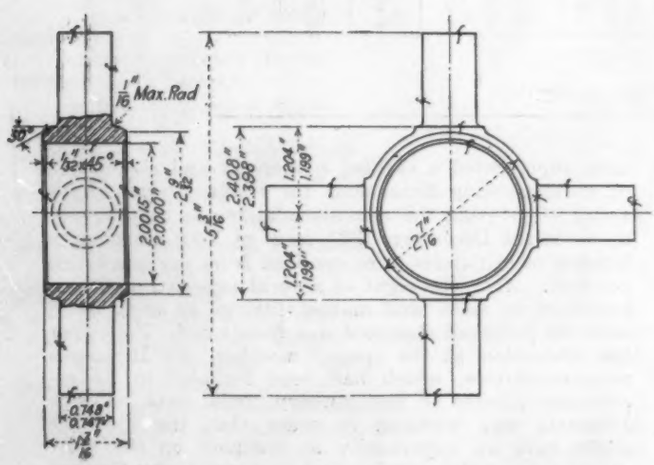
After Hardening, the Spider Arms Shall Lie in the Same Plane within 0.003 In. and 90 Deg. apart within 0.003 In. The Oil-Holes and Grooves Shall Be According to the Requirements of Each Individual Design



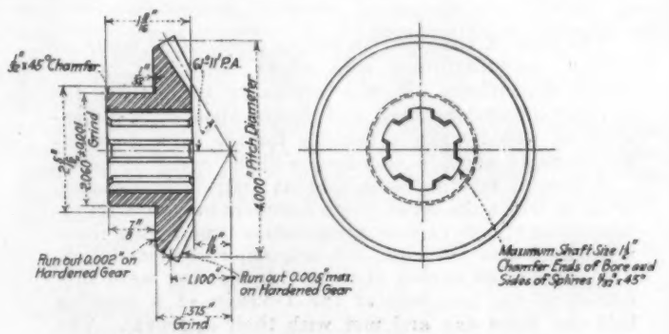
TEN-TOOTH PINION FOR 18-TOOTH SIDE-GEAR


1/32" x 45° Chamfer
60°37' P.A.
3.600" Pitch Diameter
Run out 0.002" on Hardened Gear
Run out 0.005" maximum on Hardened Gear
Maximum Shaft Size 1 3/8"
Chamfer Ends of Bore and Sides of Splines 1/32" x 45°
1.281" Grind

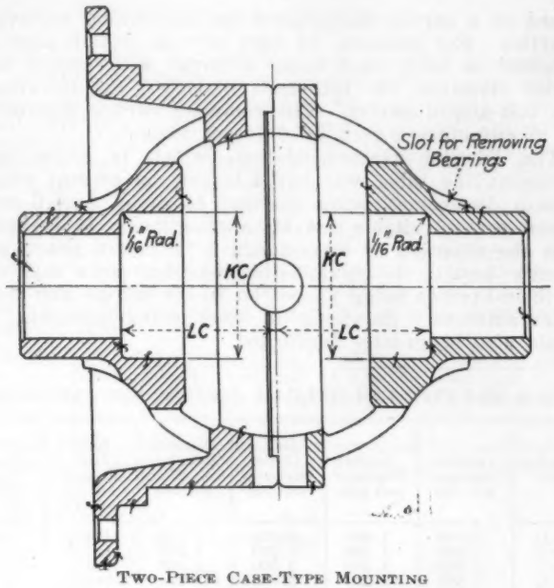
EIGHTEEN-TOOTH SIDE-GEAR FOR CASE MOUNTING



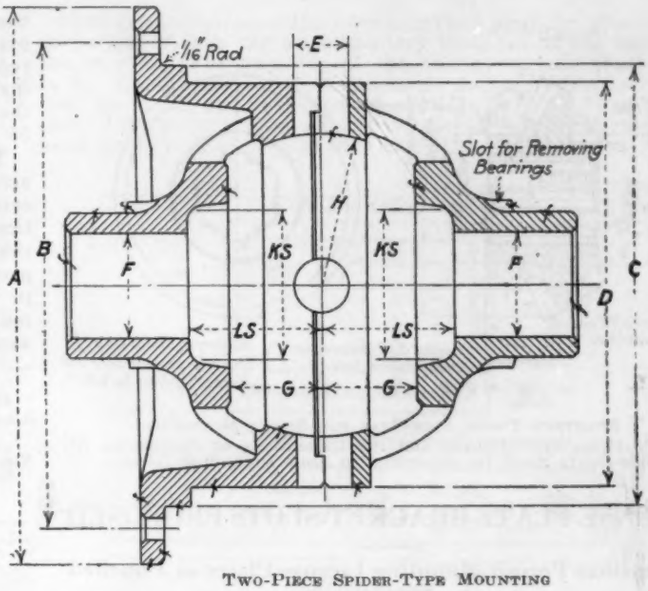
SPIDER FOR 10-TOOTH PINION AND 18-TOOTH SIDE-GEAR


1/32" x 45° Chamfer
61°11' P.A.
4.000" Pitch Diameter
2.060" +0.001" Grind
Run out 0.002" on Hardened Gear
Run out 0.005" max. on Hardened Gear
Maximum Shaft Size 1 1/4"
Chamfer Ends of Bore and Sides of Splines 1/32" x 45°
1.375" Grind

TWENTY-TOOTH SIDE-GEAR FOR CASE MOUNTING



TWO-PIECE CASE-TYPE MOUNTING

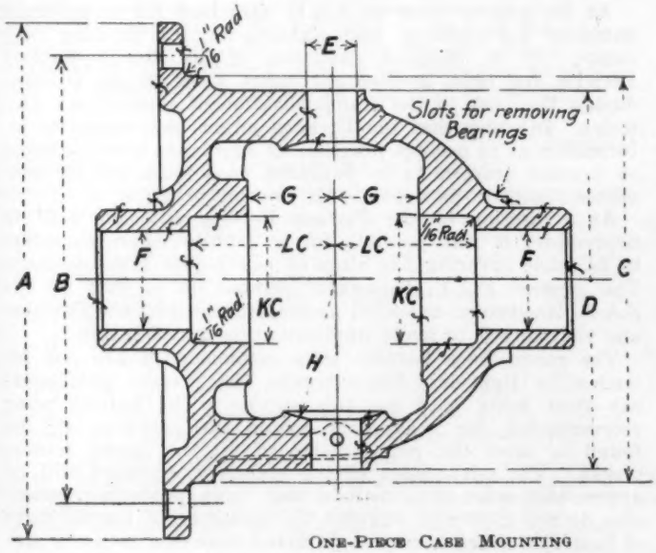


TWO-PIECE SPIDER-TYPE MOUNTING

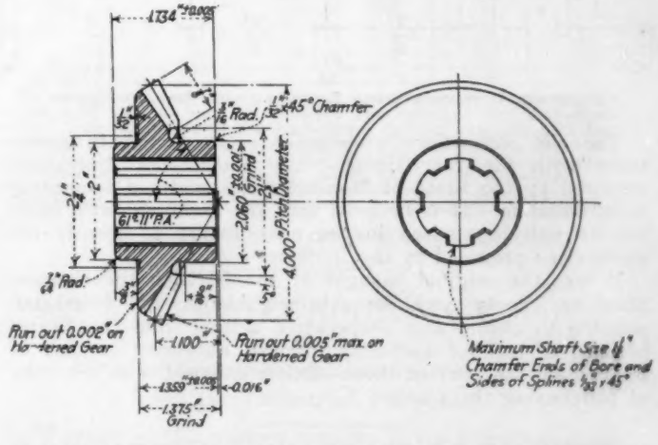
CASE DIMENSIONS FOR SPIDER AND CASE SIDE-GEAR MOUNTING

Model	Inside Gears	*A*	*B* ±0.003	Number of Holes	Drill Size	*C* +0.000 −0.002	*D*	*E* ±0.001	*F* Maximum	*G* ±0.001	*H* ±0.001	*KS*	*LS*	*KC* +0.0015 −0.0000	*LC*
1	18-10	7 5/16	6.625	12	21/64	6.000	5 1/2	0.750	1 1/16	1.283	2.079	2 1/16	1 13/16	2.0000	2 1/16
2	20-11	8 1/16	7.125	12	21/64	6.500	6	0.750	1 1/16	1.377	2.315	2 1/16	1 7/16	2.0630	2 3/16

Oil-holes and grooves and proportions for strength shall be according to the requirement of each individual design. The case shall be designed, however, for the maximum practical rigidity.



ONE-PIECE CASE MOUNTING


1.134" +.000 −.005
1/16" Rad.
1" 32
45° Chamfer
2.060" +.000 −.005 Grind
6 Key Pitch Diameter
4.000" Pitch Diameter
1/8" Rad.
Run out 0.002" on Hardened Gear
1.100
Run out 0.005" max. on Hardened Gear
1.359" +.000 −.016"
1.375" Grind
Maximum Shaft Size 1/4" Chamfer Ends of Bore and Sides of Splines 1/32" x 45°

TWENTY-TOOTH SIDE-GEAR FOR SPIDER MOUNTING

DIMENSIONS FOR THE ONE-PIECE CASE MOUNTING

Model	Inside Gears	*A*	*B* ±0.003	Number of Holes	Drill Size	*C* +0.000 −0.002	*D*	*E* +0.001 −0.000	*F* Maximum	*G* ±0.001	*H* ±0.001	*KC* +0.0015 −0.0000	*LC*
1A	18-10	7 5/16	6.625	12	21/64	6.000	5 5/16	0.750	1 1/16	1.283	2.079	2.0000	2 1/16
2A	20-11	8 1/16	7.125	12	21/64	6.500	6 1/16	0.750	1 1/16	1.377	2.315	2.0630	2 3/16

Oil-holes and grooves and proportions for strength shall be according to the requirement of each individual design. The case shall be designed, however, for the maximum practical rigidity.

Run out 0.002 on Hardened Gear
Run out 0.005 maximum on Hardened Gear
Maximum Shaft Size
Chamfer Ends of Bore and Sides of Splines
Grind

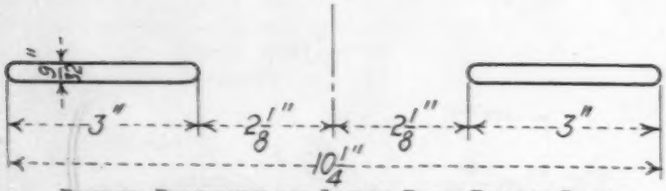
EIGHTEEN-TOOTH SIDE-GEAR FOR SPIDER MOUNTING

The Oil-Holes and Grooves and the Dimensions of Splines on All Side-Gears Shall Be According to Each Individual Design

LICENSE-PLATE BRACKET-SLOTS PROPOSED

Dimensions Permit Mounting License-Plates as Punched by the Different States

The Parts and Fittings Division has submitted to the Standards Committee for adoption as S.A.E. Standard the license-plate bracket-slot dimensions that are given in the accompanying drawing. These dimensions were adopted only after a careful analysis of the practice of the States of the Union indicated that the plates of all States could be mounted on brackets slotted as shown, provided holding screws larger than ¼ in. are not used. All of the State plates would be centered on the brackets, with the exception of the Florida plate, which would be 1 in. off-center.



PROPOSED DIMENSIONS FOR LICENSE-PLATE BRACKET-SLOTS

The slot dimensions proposed are practically in agreement with the rear license-plate bracket-slot dimensions required by the State of Massachusetts under a temporary understanding. It is believed that the Massachusetts regulations will be revised in the near future to specify the dimensions proposed by the Division.

It was the original thought of the Division that license-plate uniformity could be obtained, but it was found impossible to obtain any cooperative action from the States because of lack of authority, divided authority or lack of interest on the part of those officials charged with the duty of purchasing the plates.

FLEXIBLE-DISC STANDARD RECOMMENDED

Needless Variety of Sizes Used for Generator, Distributor and Water-Pump Drives

At the time the present S.A.E. Recommended Practice for Propeller-Shaft Flexible-Discs was formulated by the Parts and Fittings Division, it was decided to extend the standard to include flexible-discs intended for generator, water-pump and distributor drives. Information was obtained from engine makers and automobile makers building their own engines as to the dimensions of such flexible-discs used.

At a meeting of the Parts and Fittings Division members in October, a definite series of sizes was approved for adoption as S.A.E. Recommended Practice, the series being based on a survey that showed an astonishing variation in practice. For instance, 13 sizes of 3-in. flexible-discs were reported as used, each being different with regard to the inside diameter, the bolt-circle diameter, the thickness or the bolt-hole diameter. The complete survey showed that 55 manufacturers used 48 different sizes.

The Division recommendation, which is given in the accompanying table, was based largely on present practice, certain dimensions being changed to make a well-proportioned series suitable for all applications. It is believed that the adoption of this standard in future practice will greatly benefit the flexible-disc manufacturers and result in their savings being passed on to the engine and the car manufacturers. Servicing of cars using standard sizes would also be greatly facilitated.

FOUR-BOLT-TYPE NON-METALLIC FLEXIBLE-DISC DIMENSIONS

Nominal Size	Outside Diameter ±0.020	Inside Diameter ±0.020	Bolt-Circle Diameter ±0.008	Distance Between Bolt-Holes ±0.010	Bolt-Hole Diameter +0.010 —0.000	Thickness +0.020 —0.010
2¾ x¼	2.750	1.000	2.000	1.414	0.250	0.250
3 x¼	3.000	1.250	2.250	1.591	0.250	0.250
3¼ x¼	3.250	1.250	2.500	1.768	0.312	0.250
3½ x¼	3.500	1.250	2.750	1.944	0.312	0.250
3¾ x¼	3.750	1.250	3.000	2.121	0.312	0.250
4 x¼	4.000	1.500	3.125	2.210	0.312	0.250

FIVE TRUCK-BATTERIES RECOMMENDED

Standard Will Cover Heavy-Duty Truck as Well as Passenger-Car Batteries

In the last several years passenger-car starting-and-lighting batteries have gradually been reduced to seven standard sizes that as made by the different battery manufacturers are interchangeable. This was accomplished through the active cooperation of the car and battery manufacturers, aided by the Storage-Battery Division.

At the present time no S.A.E. Standard for motor-truck batteries for starting and lighting or for lighting only exists. W. E. Holland, chairman of the Storage-Battery Division for 1924, devoted the entire work of the Division during the year to the standardization of motor-truck batteries. In order that the Division might have complete information as to present practice, as standards must be based on present practice to be workable, each truck builder submitted complete data as to his present practice.

At a meeting of the Storage Battery Division, held in September, it was possible for a definite recommendation to be made covering five sizes of heavy-duty truck battery. The present S.A.E. Standard, printed on p. B23 of the S.A.E. HANDBOOK, extended as recommended by the Division and rearranged to avoid duplication, is given herein.

The motor-truck battery sizes recommended are not intended for light-duty motor-trucks, the present passenger-car sizes being used for this service. The battery sizes recommended for heavy-duty motor-truck service will be found to meet the requirements of all the larger motor-trucks. The advantages of the standard proposed will be appreciated when it is realized that truck production schedules do not generally warrant the existence of special sizes of battery for truck makers, it being desirable to use a size that can be obtained readily from the battery manufacturers.

The reduction to practice of the standard for motor-truck batteries will be absolutely impossible without the active cooperation of the truck builders. If they are not in favor of restricting their purchases to the sizes standardized, battery manufacturers can be found who will make non-standard sizes. On the other hand, truck builders not entirely "sold" on the importance of standardizing truck batteries can be influenced to abide by the standard sizes adopted, provided the battery manufacturers appreciate the importance of limiting production to only standard sizes and will explain matters clearly to such prospective purchasers.

STORAGE-BATTERIES

Application.—These specifications are intended to apply only to lead-acid storage-batteries for automotive equipment.

Ratings.—Batteries for combined starting and lighting service shall have two ratings. The first rating shall indicate the lighting ability and shall be the capacity in ampere-hours of the battery when it is discharged continuously at the 5-hr. rate to a final voltage of not less than 1.7 per cell, the temperature of the battery at the beginning of such discharge being 80 deg. fahr. The second rating shall indicate the starting ability and shall be the capacity in ampere-hours of the battery when it is discharged continuously at the 20-min. rate to a final voltage of not less than 1.5 per cell, the temperature of the battery at the beginning of such discharge being 80 deg. fahr.

Location of Battery Parts.—The location and polarity of the terminal posts and the position of the handles and the name-plates shall be as shown in the accompanying illustration.

Terminal Posts.—When taper posts are used for terminals of lead-acid storage-batteries, the dimensions in inches shall be:

Small Diameter of Negative Post	5/8
Small Diameter of Positive Post	11/16
Taper per Foot	1 1/3
Minimum Length of Taper	11/16

MOTOR-TRUCK STORAGE-BATTERIES

These specifications are intended to apply only to lead-acid storage-batteries for heavy-duty motor-trucks.

Compartments.—Battery compartments shall be of metal of not less than No. 18 U. S. S. gage (0.050 in.), and supported entirely by the chassis.

The inside width of the compartments shall be 8 in. and the height from the bottom shall be 11½ in. The inside length shall be 12, 14¾, 15½ or 18¾ in.

The battery shall rest on two wooden strips, each 2 in. wide and ¼ in. thick, running lengthwise of the compartment and positively spaced with the edges flush with the sides of the battery.

Hold-Down Devices.—Hold-down devices shall be attached at the top of each end of the battery case, not at the top of the handles. The diameter of the hold-down rods shall be 5/16 in. The diameter of the rod holes in the hold-down devices shall be 7/16 in., and their centers shall be ½ in. from the ends of the battery case. Hold-down devices shall not extend more than ¾ in. beyond each end of the battery case.

MOTOR-TRUCK STORAGE-BATTERY DIMENSIONS

Battery No.	No. of Cells[1]	Minimum Capacity, Amp-Hr.		Maximum Overall Dimensions, In.		
		5-Hr. Rate	20-Min. Rate	Length[2]	Width	Height
11	3	45	....	10¼	7⅝	10¾
12	3	60	....	12½	7⅝	10¾
13	3	75	37	13⅝	7⅝	10¾
14	3	90	45	15¾	7⅝	10¾
15	3	105	52	17	7⅝	10¾

[1] Side-to-side assembly of cells shall be used as shown in the top drawing.

[2] The overall end-to-end length includes handles, but not hold-down devices. The handles and the hold-down devices shall be attached only to the ends of the case. Terminals and connections shall not extend above the handles; the latter shall be the highest point.

Batteries Nos. 11 and 12 are for lighting service only; batteries Nos. 13, 14 and 15 are for combined starting and lighting service.

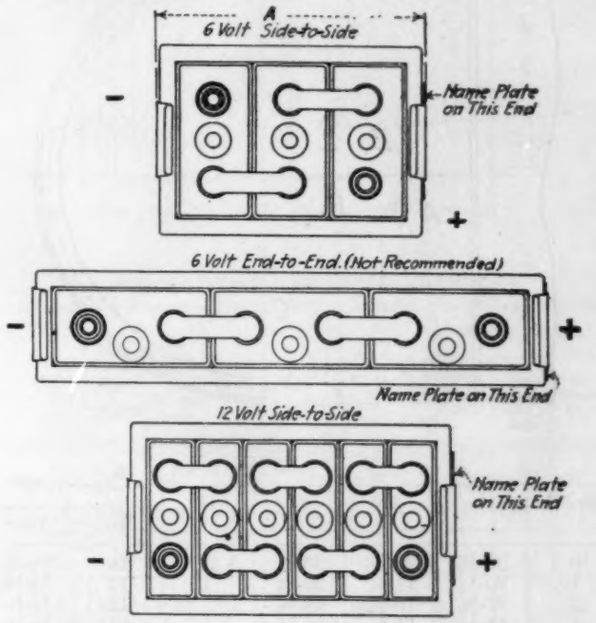
PASSENGER-CAR STORAGE-BATTERIES

Compartments.—Compartments for passenger-car starting and lighting batteries shall be of metal of not less than No. 18 U. S. S. gage (0.050 in.) and supported entirely by the chassis.

The inside width of the compartments shall be 8 in. and the height from the bottom shall be 10½ in. The inside length shall be 12, 13½, 14¾ or 18¾ in.

The battery shall rest on two wooden strips, each 2 in. wide and ¼ in. thick, running lengthwise of the compartment and positively spaced with the edges flush with the sides of the battery.

Hold-Down Devices.—Hold-down devices shall be attached at the top of each end of the battery case, not at the top of the handles. The diameter of the hold-down rods shall be ¼ in. The diameter of the rod holes in the hold-down devices shall be ⅜ in., and their centers shall be 3/16 in. from the ends of the battery case. Hold-down devices shall not extend more than 17/32 in. beyond each end of the battery case.



PASSENGER-CAR STORAGE-BATTERY DIMENSIONS

Battery No.	No. of Cells	Minimum Capacity, Amp-Hr.		Maximum Overall Dimensions, In.[1]		
		5-Hr. Rate	20-Min. Rate	Length (*A*)	Width	Height
1	3[a]	60	31	9⅛	7⅛	10
2	3[a]	72	37	10⅜	7⅛	10
3	3[a]	84	43	12⅜	7⅛	10
4	3[a]	96	50	13½	7⅛	10
5	3[b]	95	43	20⅝	5⅛	9½
6	6[c]	36	19	12⅜	7⅛	10⅛
7	6[a]	60	31	17⅜	7⅛	10

[1] The overall end-to-end length of passenger-car batteries for starting and lighting service includes handles, but not hold-down devices. The handles and the hold-down devices shall be attached only to the ends of the case. Terminals and connections shall not extend above the handles; the latter shall be the highest point.

[a] Arrangement of cells to be as shown in the top drawing.

[b] End-to-end assembly of jars shown in middle drawing is not recommended because of the inherent weakness of this type of construction.

[c] Arrangement of cells to be as shown in bottom drawing.

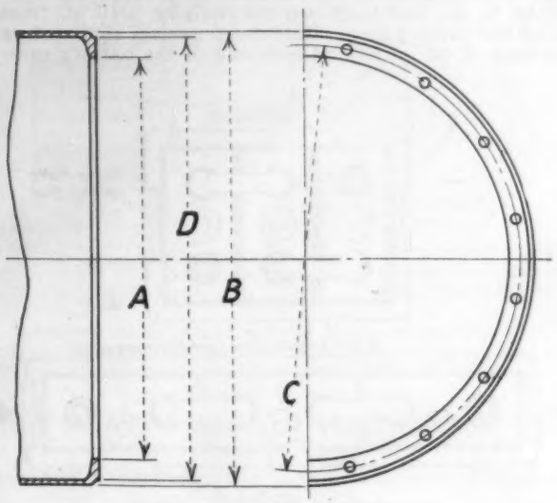
NO. 0 FLYWHEEL-HOUSING ADDED

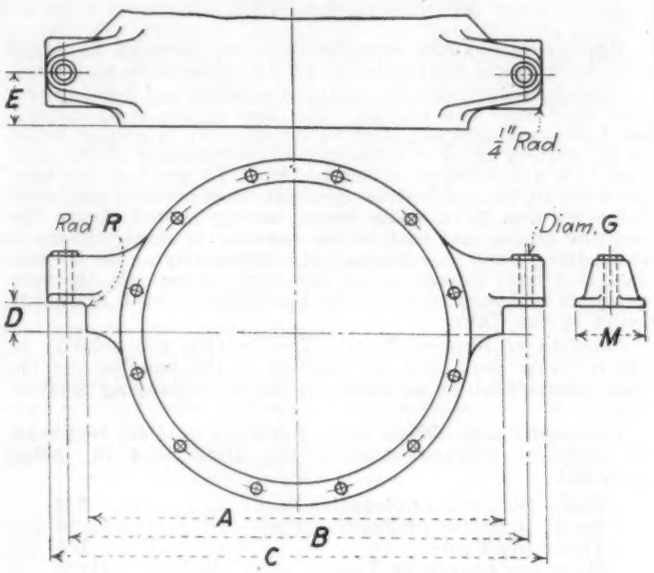
Engine Division Recommends Dimensions for Housings Used for Industrial Purposes

As a result of information brought to the attention of the Engine Division to the effect that industrial applicaions of internal-combustion engines necessitated the use of flywheels larger than could be accommodated by the largest, or No. 1, S.A.E. Flywheel Housing, the Engine Division has determined upon suitable dimensions for a No. 0 size of housing. The present S.A.E. Standard, now printed on p. A1 of the S.A.E. HANDBOOK, revised as proposed by the Division, is given herewith.

It is understood that engines used for industrial applications develop as much as 100 hp. at 1000 r.p.m. For these the 20-in. flywheel used with the No. 1 housing is entirely too small to smooth-out the engine torque and take care of sudden loads. Owing to the lack of a suitable standard for the engine builders to follow in the past, the housings now being used for this size of engine are slightly different and require the designing of corresponding clutch housings. The

clutch manufacturers are consequently faced with the problem of making several sizes of housing for engines of about the same displacement.





Size No.	A	B	C	D	Cap-Screws[1]	
					No.	Size
0	25-1/2	28-1/2	26-3/4	28	16	1/2-13
1	20-1/8	21-3/4	20-7/8	....	12	3/8-16
2	17-5/8	19-1/4	18-3/8	....	12	3/8-16
3	16-1/8	17-3/4	16-7/8	....	12	3/8-16
4	14-1/4	15-7/8	15	....	12	3/8-16
5	12-3/8	14	13-1/8	...	8	3/8-16

[1] Cap-Screws shall be threaded in accordance with the Free-Fit (Class 2) Tolerances of the S.A.E. Standard for Screw-Threads and shall be equally spaced on each side of the vertical center-line.

The tolerance for the flywheel-housing bore shall be plus 0.005 in. and minus 0.000, and the maximum eccentricity 0.005 in. (indicator reading, 0.010 in.); except for the No. 0 size, which shall be plus 0.010 in. and minus 0.000.

The maximum deviation of the face of the flywheel-housing flange from its true position, when the housing is rotated on its axis, shall be 0.003 in. (indicator reading, 0.006 in.)

Size No.	A	B	C	D	E	G	R Max.	M
1	23-1/2	26-3/4	28-3/4	2	3	25/32	7/16	4
2	23-1/2	26-3/4	28-3/4	2-1/2	3	25/32	3/8	3-1/2
3	23-1/8	24-1/2	25-3/4	2-1/2	3	21/32	1/4	3-1/2
4	23-1/8	24-1/2	25-3/4	2-1/2	3	21/32	1/4	2-3/4
5	23-1/8	24-1/2	25-3/4	2-1/2	3	21/32	1/4	2-3/4
2T[1]	20	21-3/4	23-1/2	3	3	21/32	1/4	4

[1] Size No. 2T is intended primarily for tractor engines.

SUPPORT-ARM WIDTHS DECIDED UPON

Extension of Present S.A.E. Standard Recommended by Engine Division

The present S.A.E. Standard for Engine Rear Support-Arms, p. A3 of the S.A.E. HANDBOOK, does not specify the width of the support arms. As the Engine Division believed that for this dimension present practice for the unit powerplant type of construction had crystallized to a considerable extent, a survey of current practice was made. From the data received it was found possible for the Division members to select definite dimensions for the width of the bottom face of the arms. The dimensions recommended are specified in the last column of the accompanying table, which gives the present S.A.E. Standard for Engine Support-Arms, extended to include the dimensions now recommended for adoption.

The widths recommended are such as to permit the use of anti-squeak pads. Definite heights for the support arms were not recommended by the Division as the height covers only the bolt length and standardization would tend to restrict design.

The standard for Engine Support-Arms does not apply to the front mounting. Standardization of this engine support is now being considered by the Division, a Subdivision having been recently appointed to obtain information on present practice and to draw up a preliminary recommendation.

COMPOSITION CHANGE RECOMMENDED

S.A.E. Specification No. 69 for Wrought Aluminum-Bronze Difficult To Meet

The composition ranges specified for the present S.A.E. Specification for Wrought Aluminum-Bronze, p. D112 of the S.A.E. HANDBOOK, are such that if the minimum copper-content permissible and the maximum permissible contents of the other materials are added together, the total will be 99.25 per cent, whereas, if the maximum content of the copper is used with the minimum content of the other materials, the total will be 96.50 per cent. It is, therefore, difficult for the manufacturers of this alloy to comply with the specification. The Non-Ferrous Metals Division recommends that the specification be revised to specify a copper-content of from 87 to 89, instead of from 85 to 87 per cent. The complete composition of this alloy in percentage is given below:

Copper	85.00 to 87.00
Aluminum	7.00 to 9.00
Iron	2.50 to 4.50
Tin (none desired) max.	0.50
Other Impurities, max.	0.25

HEAD-LAMP STANDARD REVISED

Maximum Head-Lamp Mounting-Height of 42 In. Limited to Passenger Cars

Although the present S.A.E. Standard for Head-Lamps was approved in July, 1924, by the voting members of the Society

for adoption as S.A.E. Standard, it was criticised by one member to the effect that the 42-in. maximum mounting-height should not apply to motor trucks or motorcoaches inasmuch as with the larger vehicles it is inadvisable to mount head-lamps so low and also because better illumination may be obtained with head-lamps mounted on the fenders, but with the beams tilted downward, thus causing shorter shadows to be cast by the inequalities in the road.

The Lighting Division has therefore recommended that the present S.A.E. Standard for Head-Lamps, page B1 of the S.A.E. HANDBOOK, shall be revised to limit the maximum height of 42 in. to passenger-car head-lamps only.

HINGE STANDARDS AGREED UPON

Manufacturers Confer in Detroit with Members of Passenger-Car Body Division

As a result of considerable criticism of the Passenger-Car Body Division's recommendation for door hinges, which was circularized for comment in July of this year, representatives of hinge manufacturers were invited to meet the members of the Passenger-Car Body Division in Detroit on Oct. 27. A general discussion of the Division's original recommendation indicated considerable difference in practice which would not permit of standardization unless it were definitely understood that any standard proposed was not intended for immediate adoption. On this basis, several changes were made in the Division's recommendation, the more important of which are as follows:

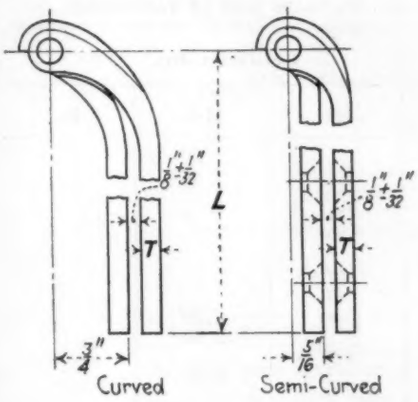
(1) The dimension from the center-line of the pin to the face of the plates is to be taken from the inner side of the inner plate instead of from the inner side of the outer plate, because the former dimension is the important one to the body builder

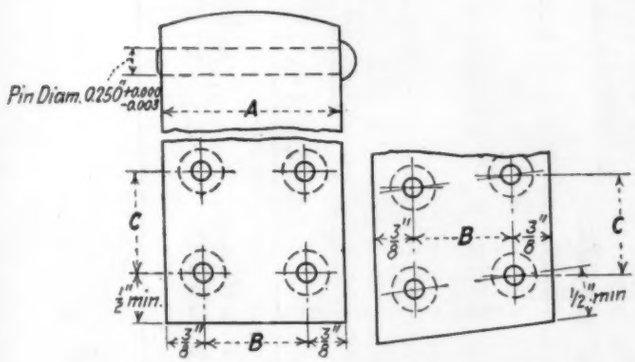
(2) It was decided not to specify the reamed hole for the pin, inasmuch as no necessity for interchangeability exists and the pin-hole dimensions should be set by each manufacturer for his own product. The negative tolerance on the pin diameter was increased to 0.003 in., to meet more nearly present practice for pins with upset heads

(3) The distance from the end of the hinge plate to the first row of screw-holes was changed to ½ in. minimum, to give the screws a stronger grip in the door pillars

It was stated that the full-curved type of hinge is apparently being superseded by the semi-curved and straight types, and that the concealed type is being used to a less extent than formerly. As the straight type is less expensive and is used on very many cars, as well as motor-truck cabs, dimensions were proposed for this type by a hinge manufacturer. The hinge dimensions proposed are given in the accompanying drawings and tables.

The recommendations will be submitted to the Standards Committee for approval as S.A.E. Recommended Practice, having been approved by the Passenger-Car Body Division by letter ballot.

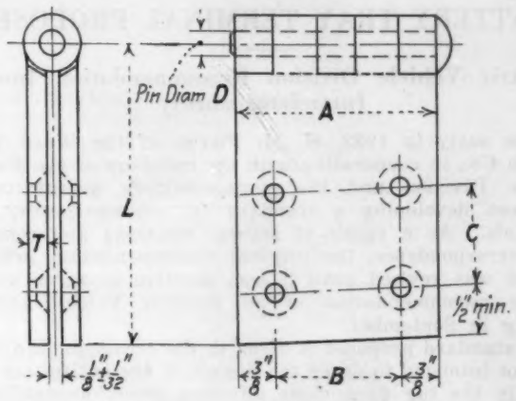




CURVED AND SEMI-CURVED HINGE DIMENSIONS

Width A	Number of Joints	L	B	C (Min.)
1¾	3 or 5	3, 4, 5 or 5½	1	1
2	5	3, 4, 5 or 5½	1¼	1

Dimensions in inches.
Screw-holes shall be countersunk to 0.438 in. x 82 deg. for No. 12 wood-screws.
Plate Thickness (*T*)—For malleable and forged hinges, the thickness shall be ¼ plus or minus 1/32 in.; for pressed-steel hinges, ⅛ or ¼ plus or minus 0.005 in.



STRAIGHT-TYPE DOOR-HINGE DIMENSIONS

Width A	Plate Thickness T ±0.005	Pin Diameter D +0.000 −0.003	Number of Joints	L	B	C (Min.)	Number of Hinges for Light Jobs	Number of Hinges for Medium Jobs	Number of Hinges for Heavy Jobs
1¾	0.160	0.273	3 or 5	3, 4, 5 or 5½	1	1	3	4	.....
1¾	0.187	0.273	3	3, 4, 5 or 5½	1	1	3	4	4
2	0.160	0.273	5	3, 4, 5 or 5½	1¼	1	3	3	4
2	0.187	0.273	5	3, 4, 5 or 5½	1¼	1	3	3	3

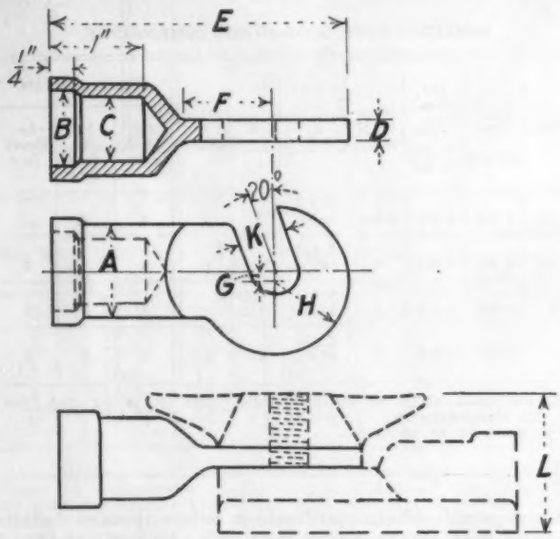
Screw-holes shall be countersunk 0.438 in. x 82 deg. for No. 12 wood-screws.
Dimensions in inches.

BATTERY TRAY TERMINAL PROPOSED

Electric Vehicle Division Recommendation Insures Interchangeability

Since early in 1922, H. M. Pierce, of the Ward Motor Vehicle Co., in cooperation with the members of the Electric Vehicle Division and the storage-battery manufacturers, has been developing a standard for storage-battery tray terminals. As a result of several meetings and considerable correspondence, the original recommendation proposed in 1922 was revised until it was possible to agree upon a definite recommendation at an Electric Vehicle Division Meeting in September.

The standard proposed is given in the accompanying table. It is not intended to cover the design of the entire terminal, but only the lug dimensions affecting interchangeability.



Terminal Number	2	0	0000
Bolt	3/8-16	3/8-16	1/2-13
A	23/32	27/32	1
B	1/2	11/16	27/32
C	13/32	17/32	11/16
D	3/16	3/16	1/4
E	2 1/8	2 1/8	2 5/16
F (Min.)	13/16	13/16	1
G	3/32	3/32	1/8
H	5/8	5/8	13/16
K	7/16	7/16	9/16
L (Max.)	1 1/4	1 1/4	1 5/8

Bolts shall be made of steel and the thread shall be in accordance with the S.A.E. Free-Fit (Class 2) Tolerances.

TAP-DRILL REFERENCE TABLES

List of Drills Indicates Those Suitable for Different Minor-Diameter Limits

Believing that it is highly desirable to establish definite drill-sizes for the bore diameters specified in the report of the Sectional Committee on Screw-Threads, which was approved at the January, 1923, Meeting of the Standards Committee, the Screw-Threads Division has prepared Tap-Drill Reference Tables for the theoretical, the minimum and the maximum minor-diameters for all tapped holes specified in the S.A.E. Extra-Fine, the Fine and the Coarse Screw-Thread Series.

The purpose of these reference tables is to list drills that are suitable for use as tap-drills for screw-thread depths of three-quarters and five-sixths of the theoretical thread-depth and for the full theoretical depth. They are not intended to indicate a specific tap-drill, as the size of tap-drill best suited to a given application is dependent upon the material, the nature of the cutting lubricant, the method of drilling and tapping and the condition of the cutting edges of the drill.

Under conditions where the drill can be depended upon to produce a hole somewhat larger than itself, it may be safe to use a tap-drill smaller than the minimum minor-diameter; on the other hand, if conditions are such that a tap-drill may be depended upon to cut a hole its exact size or even slightly smaller, it may be safe to use a drill larger than the maximum minor-diameter, the extent depending upon how much the minor diameter is reduced in tapping.

The tables include tap-drills for S.A.E. Coarse, Fine and Extra-Fine Screw-Threads as shown on p. C1 of the S.A.E. HANDBOOK. The bore, after threading with the tap-drill suggested for general use, may not in some cases be within the prescribed minor-diameter limits; but screws in accordance with the S.A.E. Specifications will assemble with them without minor-diameter interference. The tables are limited to drill sizes up to and including 1¼ in., because larger holes are usually reamed before tapping.

TABLE 1—PROPOSED STANDARD LIST OF TAP-DRILLS

Tap Size		Tap-Drill Size		
Diameter	Threads Per Inch	No.	Mm.	In.
0	80	....	1.20	....
1	64	....	1.45	....
1	72	53	....	....
2	56	51	....	....
2	64	50	....	....
3	48	47	....	....
3	56	46	....	....
4	40	44	2.20	....
4	48	....	2.30	....
5	40	39	....	....
5	44	....	2.60	....
6	32	....	2.70	....
6	40	34	....	....
8	32	....	3.30	....
8	36	29	....	....
10	24	26	....	....
10	32	21	....	....
12	24	17	4.40	....
12	28	15	....	....
1/4	20	8	....	....
1/4	28	....	5.40	....
5/16	18	....	6.40	....
5/16	24	....	6.80	....
3/8	16	....	7.90	....
3/8	24	....	8.40	21/64
7/16	14	....	9.20	23/64
7/16	20	....	9.80	....
1/2	13	....	10.5	27/64
1/2	20	....	11.5	7/16
9/16	12	....	12.0	15/32
9/16	18	....	....	1/2
5/8	11	....	....	17/32
3/4	10	....	16.5	41/64
3/4	16	....	....	11/16, 43/64
7/8	9	....	....	49/64, 3/4
7/8	14	....	....	51/64
1	8	....	22.0	....
1	14	....	....	59/64
1 1/8	7	....	25.0	31/32
1 1/8	12	....	26.5	1 1/32
1 1/4	7	....	28.0	1 3/32
1 1/4	12	....	29.5	1 5/32

TABLE 2—DRILL SIZES FOR MINOR DIAMETERS OF THE COARSE-THREAD SERIES

Diameter	Threads Per Inch	Bore, Full Thread Depth[1]	Drill Size		Bore, 5/6 Thread Depth[2]	Drill Size		Bore, ¾ Thread Depth[3]	Drill Size	
			Dec.	Nom.		Dec.	Nom.		Dec.	Nom.
1	64	0.05270	0.0532	1.35 mm.	0.05609	0.0551	1.40 mm.	0.05778	0.0571	1.45 mm.
2	56	0.06280	0.0630	1.60 mm.	0.06667	0.0669	1.70 mm.	0.06860	0.0689	1.75 mm[a]
3	48	0.07194	0.0728	1.85 mm.	0.07645	0.0768	1.95 mm.	0.07870	0.0785	No. 47
4	40	0.07952	0.0807	2.05 mm.	0.08494	0.0846	2.15 mm.	0.08764	0.0866	2.20 mm.
5	40	0.09252	0.0925	2.35 mm.	0.09794	0.0980	No. 40	0.10064	0.0995	No. 39
6	32	0.09741	0.0980	No. 40	0.10417	0.1040	No. 37	0.10755	0.1065	No. 36
8	32	0.12341	0.1250	1/8	0.13017	0.1299	3.30 mm.	0.13355	0.1338	3.40 mm[a]
10	24	0.13587	0.1360	No. 29	0.14489	0.1440	No. 27	0.14941	0.1495	No. 25
12	24	0.16187	0.1614	4.10 mm.	0.17089	0.1719	11/64	0.17541	0.1732	4.40 mm.
¼	20	0.18505	0.1850	No. 13	0.19587	0.1960	No. 9	0.20129	0.2010	No. 7
5/16	18	0.24033	0.2402	6.1 mm.	0.25236	0.2520	6.4 mm.	0.25837	0.2570	F
3/8	16	0.29381	0.2950	M	0.30734	0.3071	7.8 mm.	0.31411	0.3125	5/16
7/16	14	0.34471	0.3464	8.8 mm.	0.36018	0.3594	23/64	0.36791	0.3680	U
½	13	0.40001	0.4040	Y	0.41673	0.4134	10.5 mm.[a]	0.42506	0.4219	27/64
9/16	12	0.45425	0.4531	29/64	0.47229	0.4724	12.0 mm.	0.48131	0.4844	31/64
5/8	11	0.50691	0.5118	13.0 mm.	0.52659	0.5312	17/32	0.53653	.....	.....
¾	10	0.62010	0.6250	5/8	0.64175	0.6406	41/64	0.65257	0.6496	16.5 mm.
⅞	9	0.73066	0.7344	47/64	0.75472	0.7500	¾	0.76675	0.7656	49/64
1	8	0.83762	0.8437	27/32	0.86468	0.8661	22.0 mm.	0.87822	0.8750	⅞
1⅛	7	0.93942	0.9375	15/16	0.97035	0.9687	31/32	0.98582	0.9844	63/64
1¼	7	1.06442	1.0625	1 1/16	1.09535	1.0937	1 1/32	1.11082	1.1093	1 7/64

[1]Theoretical thread-depth.
[2]Minimum minor-diameter.
[3]Maximum minor-diameter.
[a]The nearest drill-size available is outside the minor-diameter limits by more than ½ of 1 per cent of the diameter.

TABLE 3—DRILL SIZES FOR MINOR DIAMETERS OF THE FINE-THREAD SERIES

Diameter	Threads Per Inch	Bore, Full Thread Depth[1]	Drill Size		Bore, 5/6 Thread Depth[2]	Drill Size		Bore, ¾ Thread Depth[3]	Drill Size	
			Dec.	Nom.		Dec.	Nom.		Dec.	Nom.
0	80	0.04376	0.0453	1.15 mm.	0.04647	0.04650	No. 56	0.04782	0.0472	1.20 mm.
1	72	0.05496	0.0550	No. 54	0.05796	0.05710	1.45 mm.	0.05947	0.0595	No. 53
2	64	0.06570	0.0670	No. 51	0.06909	0.06890	1.75 mm.	0.07078	0.0709	1.80mm.[a]
3	56	0.07580	0.0760	No. 48	0.07967	0.07850	No. 47	0.08160	0.0810	No. 46
4	48	0.08494	0.0846	2.15 mm.	0.08945	0.08900	No. 43	0.09170	0.0905	2.30 mm.
5	44	0.09548	0.0960	No. 41	0.10040	0.10150	No. 38	0.10286	0.1024	2.60 mm.
6	40	0.10552	0.1065	No. 36	0.11094	0.11100	No. 34	0.11364	0.1130	No. 33
8	36	0.12792	0.1285	No. 30	0.13393	0.13390	3.40 mm.	0.13694	0.1360	No. 29
10	32	0.14941	0.1495	No. 25	0.15617	0.15620	5/32	0.15955	0.1590	No. 21
12	28	0.16961	0.1695	No. 18	0.17734	0.17700	No. 16	0.18120	0.1811	4.60 mm.
¼	28	0.20361	0.2040	No. 6	0.21134	0.21260	5.4 mm.	0.21520	0.2165	5.5 mm.[a]
5/16	24	0.25837	0.2598	6.6 mm.	0.26739	0.26770	6.8 mm.	0.27191	0.2720	I
3/8	24	0.32087	0.3230	P	0.32989	0.32813	21/64[a]	0.33441	0.3346	8.5 mm.
7/16	20	0.37255	0.3740	9.5 mm.	0.38337	0.38580	9.8 mm.	0.38880	0.3898	9.9 mm.
½	20	0.43505	0.4375	7/16	0.44587	.....	.....	0.45129	0.4527	11.5 mm.
9/16	18	0.49033	0.4921	12.5 mm.	0.50236	0.50000	½	0.50837	0.5118	13.0 mm.
5/8	18	0.55283	0.5512	14.0 mm.	0.56486	0.56250	9/16	0.57087	0.5709	14.5 mm.
¾	16	0.66881	0.6693	17.0 mm.	0.68234	0.68750	11/16	0.68911	0.6890	17.5 mm.
⅞	14	0.78221	0.78125	25/32	0.79768	0.79688	51/64	0.80541	0.8071	20.5 mm.
1	14	0.90721	0.90625	29/32	0.92268	0.92188	59/64	0.93041	.....	.....
1⅛	12	1.01680	1.0156	1 1/64	1.03480	1.03130	1 1/32	1.04380	1.0433	26.5 mm.
1¼	12	1.14180	1.1406	1 9/64	1.15980	1.15630	1 5/32	1.16880	1.1719	1 11/64

[1]Theoretical thread-depth.
[2]Minimum minor-diameter.
[3]Maximum minor-diameter.
[a]The nearest drill-size available is outside the minor-diameter limits by more than ½ of 1 per cent of the diameter

STANDARDIZATION ACTIVITIES

(*Concluded from p. 32*)

ion of the Committee that 12-volt systems should be installed.

MR. SCAIFE:—The wording raises the question as to what is a large or a small coach. What we are primarily interested in are results, not whether it should be 2 or 12 volts. The Motorcoach Committee voted to recommend that this item be omitted.

COMMISSIONER OSBORNE:—Why is it necessary to put this in at all?

MR. CHUMAR:—To make the manufacturers install a generator instead of a little "Christmas tree" battery.

MR. TREACY:—Several coach-makers put nothing but a passenger-car generator on a coach chassis. It is practically impossible to get proper lighting with that sort of generator, so we demand a generator sufficient to take care of the lighting system.

MR. SCRAGG:—I do not think the statement that you have to have a proper generator to get proper lighting is wholly correct. In the last few years the tendency in design has been to do away with the generator entirely. I think the provision requiring 5 rated cp. per passenger-seat takes care of the lighting, whether it is done with a generator or without one. I think the large companies are considering the use of no generator at all, but plan to use a storage-battery and replace it with another battery recharged in their own service-station each night. A restriction such as proposed would prohibit this.

COMMISSIONER OSBORNE:—It would not prohibit it indefinitely. When you had reached the point where you found it was more economical and better operation to do it as you indicate, it would be very easy to eliminate this procedure.

MR. SCAIFE:—We do not like the idea of specifying the voltage because it does not mean anything. You can get adequate lighting out of a 6-volt system just as well as you can out of a 12-volt system, it is just a question of capacity. Using the 32-volt system that is required for train lighting has been suggested, but we do not want to come to that.

MR. TREACY:—The battery would, of course, be sufficient without the generator, but it would mean renewing it every day.

MR. SCAIFE:—Taxicabs do it.

D. B. CARTWRIGHT:—I will have to differ with the statements made with regard to the tendency to continue the use of storage-batteries in coaches and taxicabs. The tendency now is the other way. The Fifth Avenue Coach Co. is including generators in its new equipment and the same is true of the New York City taxicab companies. The generator first used for coaches was simply the automobile generator. The coach lighting-load could not be taken care of by a generator of that capacity, however, so special generators have been developed of 225 and 300 and even of 600-watt-hr. capacity which will provide ample current.

A. C. ROY:—We have found that to get 21-cp. out of a 21-cp. lamp in motorcoach service the voltage-drop must be considered. We would prefer to see the 12-volt system adopted because of the larger current and because it would be easier to ensure the proper voltage at the lamp sockets. In that way we feel that the lamps will be allowed to burn at their proper voltage and give the proper rated-candlepower.

MR. BLAKE:—I am here as an innocent bystander, but it does seem to me that if an operator wants to use his own system of providing adequate and proper lighting, he should be allowed to do it.

COMMISSIONER OSBORNE:—Yes. Take, for instance, your own company; it may be that with the large number of coaches you have you might find it advisable to use batteries and recharge them daily, doing away with generators. I do not know.

MR. BLAKE:—I do not know either, and therefore, I do not think our hands should be tied.

COMMISSIONER OSBORNE:—I would like to have developed in proper language the requirement that would meet the situation, and, at the same time, not require something to be done that may be unnecessary. Did the Motorcoach Committee suggest some language for this?

MR. SCAIFE:—They suggested eliminating the paragraph entirely, inasmuch as it was covered in the lighting requirement in a very elaborate way.

MR. CRAWFORD:—From the discussion it would appear that the coach business is entirely in the hands of manufacturers represented in the Society of Automotive Engineers. We find that it is entirely different. Right within Newark I can name nine builders who know nothing of the Society of Automotive Engineers and we have to watch these men as well as the others.

COMMISSIONER OSBORNE:—You mean local builders?

MR. CRAWFORD:—Yes, sir. A man will go to a local coach-builder and say he wants so and so and the man will give it to him if no restrictions are imposed.

MR. BLAKE:—I would suggest the following wording: "A battery or generator of sufficient capacity to provide the specified candlepower must be provided."

COMMISSIONER OSBORNE:—If any better way of expressing this occurs to anyone after leaving this conference, he may send it in by mail and it will be considered.

Any objection to the paragraph relating to switches? That reads as follows:

> *Switch.*—All coaches shall be equipped with an approved switch of ample capacity.

MR. BLAKE:—Except the word "approved"; that is all.

MR. SCAIFE:—The Motorcoach Committee recommends the elimination of the word "approved." We do not know who will approve it.

COMMISSIONER OSBORNE:—Any comments on the provision dealing with stop-signal system? It reads:

> *Stop-Signal System.*—All coaches must be equipped with stop-signal push-buttons located between the windows of the coaches.

MR. SCRAGG:—Is it necessary to state just where the push-buttons must be placed? If they are placed directly between the windows, the person sitting on the outside will strike the person sitting next to him in the face with his elbow when he reaches for the button.

MR. SCAIFE:—I might state the phraseology the Motorcoach Committee has proposed, which is as follows: "Suitable signaling devices shall be installed in all motorcoaches within easy reach of passengers."

COMMISSIONER OSBORNE:—Why would not that meet the situation, leaving the municipalities to decide what system shall be used?

The next item is stop-lights and this paragraph reads:

> *Stop-Lights.*—All coaches must be equipped with a stop-light.

MR. CHUMAR:—I would like to add, "and kept in proper working order."

COMMISSIONER OSBORNE:—The section relating to destination and route signs reads:

> *Destination and Route Signs.*—That a route sign shall be located over the windshield on all motorcoaches and placed so that it may be read day or night from at least 100 ft. ahead of the vehicle, and must not interfere with the driver's vision or produce an annoying glare.

It occurs to me that this is more a matter of operation than construction and is out of place in these specifications.

MR. TREACY:—We feel that route signs should be provided for in these regulations.

MR. SCAIFE:—I think it is really a manufacturing proposition to build such a sign into the body.

COMMISSIONER OSBORNE:—The provision referring to radius-rods reads:

Radius-Rods.—Radius-rods shall be placed on motorcoach chassis.

MR. SCAIFE:—The Motorcoach Committee asks that this be omitted. I am not speaking for myself when I say that, because my company is about the only coach manufacturer using radius-rods today.

MR. SCRAGG:—As very few manufacturers are using radius-rods, I would like to hear, if I may, the reasons for advocating their use.

COMMISSIONER OSBORNE:—I understand that it is merely to provide an additional support and to prevent the rear axle from leaving the coach.

MR. SCRAGG:—If a spring breaks sufficiently to release the body, it will immediately fall onto the wheel. And it is conceivable that the radius-rod, as well as the spring, can break at the front end; and if it does, the front end of it will touch the ground. We use radius-rods on some types of coach and on others we do not. If springs are built properly, radius-rods are not needed and they will not serve any reasonable purpose. From a safety standpoint, we do not see anything in favor of them and we can see where they can become very dangerous.

MR. TREACY:—In coach work, where we carry from 60 to 70 passengers, we should do all in our power to protect them. With the Hotchkiss drive you are at the mercy of the springs. The radius-rod eliminates that danger. It is all right to say that the wheel-housing will support the body or keep the axle in place if a spring should break, but it is poor business. If a spring breaks, it is at least from 6 to 8 in. on both sides of the housing. Therefore, it must go one way or the other; the brakes will lock or they will fail to function.

MR. SCRAGG:—We have over 600 coaches running in this State and we are entirely willing to have it cited how many of them have had accidents owing to springs' breaking. I do not think they can tell us of any. Of 14 well-known makes of motorcoach, 11 are using Hotchkiss drives. Practically every passenger car in America today uses a Hotchkiss drive.

With the radius-rod, if the spring breaks the frame will drop and when that happens the relative position of the brake pedals will change. The argument, of course, might have a little more weight if the springs would break in two places at one time and immediately disconnect the axle from the chassis, but I have never known that to happen. The spring breaks in one place, either before or in the rear of where it is attached to the axle. If that is so, the spring is still attached, either to the front or the rear, and there is no possibility of the axle running away.

MR. BLAKE:—Our experience has been somewhat limited. We have operated only perhaps 12,000,000 or 15,000,000 coach-miles. We have had no axles break, but have had two radius-rods break, causing serious accidents.

MR. SCAIFE:—As a representative of the Motorcoach Committee I believe this should be stricken out.

MR. FENNER:—Not as being representative, but only as indicative of the trend, I would state that the commercial vehicle shows in France this year did not contain a single vehicle that did not have a Hotchkiss drive.

COMMISSIONER OSBORNE:—Any objection to the section relating to tires? It reads:

Tires.—No coach shall be operated with solid rubber tires.

MR. CHUMAR:—The statement should make it clear that the intent is to eliminate solid tires; not cushion tires.

COMMISSIONER OSBORNE:—It may be that we will consider it is unnecessary to put anything in about tires, because, if you operate with solid rubber tires over some of the streets that I have seen, nobody will ride in the coach anyway.

NEW JERSEY MOTORCOACH SPECIFICATIONS

The New Jersey Board of Public Utility Commissioners hereby fixes as a just and reasonable regulation to be observed and followed by the operators of auto buses, subject to the Board's jurisdiction the following specifications applying to such buses:

Body Specifications.—That a maximum length of body of 24 ft. and a minimum of 16 ft. in length over all be adopted. That a maximum width of 8 ft. and a minimum of 7 ft. outside measurements, and a maximum inside clearance of 6 ft. 6 in. and a minimum inside clearance of 6 ft. 4 in. be adopted

The length of the body may be subject to reduction by municipal authorities where in their judgment operating conditions require modification

Window Guards.—That suitable protection shall be provided to prevent seated passengers from inadvertently extending their arms or heads through open windows

Guard Rail.—That each bus be equipped with a suitable guard rail to prevent passengers from obstructing the view of the driver

Partition Behind Driver.—That a partition be constructed of wood and glass and located behind each driver's seat and so constructed as to permit proper ventilation at the top

Width of Door.—That there shall be a minimum clearance of at least 24 in. on the entrance and exit doors of a bus

Emergency Door.—That all motorbuses shall be provided with an emergency door located in the center rear. The door shall have a minimum clearance of 18 in. and extend from the floor to the upper belt panel

(1) All emergency doors shall be conspicuously marked "Emergency Door"
(2) Provision shall be made whereby emergency doors may be readily opened by passengers in case of emergency
(3) The rear of the bus shall be constructed so that no permanent obstruction will interfere with the passage of passengers through the emergency door
(4) The rear frame of the bus shall be so designed and constructed as to minimize as far as possible rendering the emergency door inoperative in case of accident

Panel.—That the construction of the front end of motorbus bodies shall be such as to afford the driver an unobstructed vision to the right and left. A small opening must be placed on the left-hand side of the driver to provide for signaling purposes

Handles.—That rails or grab handles must be located inside the vestibule of the bus and firmly secured by some means other than wood or lag screws

Grab Handles for Standees.—That all buses be equipped with hand rails suspended from the ceiling with sanitary fireproof straps attached, except where handles on cross-seats are used

Ventilators.—That buses be equipped with ventilators of a suitable type to assure proper ventilation

Heating System.—That a suitable heating system be installed

Gasoline Tanks.—That no bus shall be operated with the gasoline tank located inside the body of the bus; the tank must be separated from the body by fireproof material and the floor directly over the tank should also be protected by fireproof material

Mirrors.—That every bus must be provided with an inside and an outside mirror

Footboards.—That the front footboards be constructed of metal, or if of wood, protected by fireproofing material

Fire Extinguisher.—That each bus be equipped with a fire extinguisher, to be kept in proper condition and exposed to view, the same to be not less than 1-qt. capacity and to bear inspection label of Fire Underwriters' Laboratories

Inside Lights.—The interior lighting of buses shall be at least 5 rated cp. per seat passenger capacity, lamps to be so located as to provide an even distribution of lighting, and all buses shall be equipped with a step-light

Lighting installation, including generator, shall

be designed so that the lamps shall always burn at the normal brilliancy

Switch.—That all buses shall be equipped with a lighting control switch of ample capacity

Stop-Signal System.—That a satisfactory stop-signal system shall be installed

Stop-Lights.—That all buses shall be equipped with a stop-light

Route Signs.—Provision shall be made for a route sign so located that it may be read day or night from at least 100 ft. ahead of the vehicle, and must not interfere with the driver's vision or produce an annoying glare

Overhang of Bus Body.—That the maximum overhang of the motorbus body shall be in proportion of 7/24 of the total length of the vehicle

Chassis Frame.—That the chassis frame be not less than ¼-in. stock and all steel where 6-in. channel is used and not less than 3/16 in. when 8-in. channel is used, measured amidship

Height of Chassis Frame.—That the maximum height of motorbus frames from the ground to the top of the chassis frame shall be 35 in. when measured without pay load

Distance That Each Body Should Extend Beyond the Chassis.—That the body shall extend at least the full length of the chassis frame and in no case more than 10 in. beyond the end of the frame

Bumper.—That the rear bumper shall extend at least 4 in. beyond the body limits and be attached to the chassis

Brakes.—That all motorbuses shall be equipped with not less than two sets of brakes, one operated by a hand lever and the other by a pedal. Each set of brakes shall be capable of holding the vehicle when fully loaded and on a 15 per cent grade

Tires.—That no bus shall be operated with solid rubber tires. This is not intended to exclude the use of cushion tires

Wheel Housing.—That wheel housing be built for standard equipment, reinforced with at least 12 gage sheet metal or its equivalent in tensile strength. The construction of the mud-guard shall be such that no undue accumulation of dirt or foreign matter can be deposited on the body

Exhaust.—That the exhaust pipe extend to the rear end of the bus

These regulations shall apply to all buses placed in operation hereafter, for which applications for approvals of local licenses are filed and approved subsequent to the date hereof and to substitutions for existing buses. The specification referring to emergency doors applies also to all buses now operating under the Board's jurisdiction; the buses to be equipped therewith within 90 days from Dec. 18, 1924, as per the Board's regulation B-5 adopted at a meeting held on that date.

AUTOMOTIVE RESEARCH

(*Concluded from p.* 24)

tooth profile, variations of two or three thousandths either way being allowed.

Mention was made of the extensive research being carried on by the Gleason Gear Works. Gear combinations that operate satisfactorily when detached from the chassis often become noisy when installed for service. Deflections of housings and mountings are largely responsible for this trouble.

A. L. Nelson, consulting engineer, recommended that serious consideration be given to camshaft design. The tendency toward increased diameters of crankshafts should perhaps be applied to camshafts as well. Also, on account of excessive camshaft deflection, more bearings per shaft are generally needed.

R. M. Williams, of the Packard Motor Car Co., called attention to the necessity for great care in manufacture to assure quiet gears. He stated that there is an economic limit in refinements of manufacture beyond which it is not practical to go. Mr. Williams reported the use of case-hardened and accurately ground gears and felt that in certain instances the limit as regards material and accuracy consistent with economical manufacture has been reached. This at once points to the possibility of muffling gear noises by properly designing the case and the mountings.

By proper lubrication it is possible to remedy some of the trouble from noise. For example, rear axles that become noisy after 10 or 15 miles of operation accompanied by a rise in temperature can be made quiet by using a newly developed lubricant that is characterized by a high surface tension.

Erik Oberg, editor of *Machinery*, emphasized the possibility of effecting considerable improvement in gear operation by modified tooth forms. He cited examples that prove this point. Mr. Oberg believed that much more thought and effort could very profitably be concentrated upon gear problems.

A. B. Bolender, of the Warner Gear Co., mentioned the efforts of his company to eliminate gear noise by designing gear cases with extra heavy walls, by providing ample oil space between the gears and the wall and in some instances by lining the cases with sound insulating compounds. The results of these efforts indicate that the best solution lies in obtaining proper gears at the start rather than in developing methods to muffle or damp out the noise after it has been produced.

Mr. Bolender advocated grinding both sides of the gear at one setting regardless of how accurately it has been cut or how accurately the hole may be ground. Gear-grinding machines should be designed so as to make this possible. In spite of extreme care and great accuracy, however, gears are often not entirely satisfactory.

Suitably designed propeller-shafts, heavier crankshafts, heavier construction of differential housings and mountings were mentioned as important factors in the suppression of noise.

B. J. Lemon, of the United States Rubber Co., stated that noises for which gears are to blame are often laid to the tires. Furthermore, some engineers believe that tires amplify noises that originate in the gears. Reference was made to studies now in progress for the determination of noise factors as they are related to tires.

H. E. Blood, of the Detroit Gear & Machine Co., advocated the practice of assigning gear problems to gear makers who are ordinarily in a better position to specialize on them than are the automobile manufacturers.

L. D. Spence, of the Brown & Sharpe Mfg. Co., believed that in general, while the theoretical study of gearing and provisions made for scientifically testing the finished gear are essential, there is a danger of too little attention being paid to the many manual operations that must be performed on every gear. He felt that every detail in the different steps in manufacture should be studied carefully to assure equal perfection in the blank and the finished gear.

Chairman Litle characterized the gathering as a kind of nucleus for future research and discussion relative to the whole gear problem. It is hoped that one result of the meeting will be increased cooperation on the part of all concerned, namely, automotive engineers, gear manufacturers and builders of machinery designed for gear cutting and grinding.

Engineering Progress in General-Purpose Farm-Tractor Development

By O. B. ZIMMERMAN[1]

CHICAGO TRACTOR MEETING PAPER *Illustrated with* PHOTOGRAPHS

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

ABSTRACT

TYPICAL early and recent developments of the general-purpose farm-tractor are reviewed. The original steam-power equipment was intended to serve as a portable belt-power unit and was used almost entirely to operate threshing machines, many men and horses and varied supplies being needed in addition. Then, new problems developed owing to the extension of tractor usage to include plowing operations.

Internal-combustion engines were utilized in farm tractors about 20 years ago, for plowing and to supply belt-power. Other operations, such as discing, harrowing and hauling loads on highways, were attempted but, owing to the great weight of the equipment, they gave little satisfaction. Engineering effort was then directed, about 10 years ago, toward reducing the weight of tractors suitable for belt-power and drawbar work; also, to the improvement of plows, harrows, mowers and binders for use in connection with tractors. At about this time the effort was begun to effect one-man control of the tractor and its accompanying apparatus.

Power take-off, whereby power from the tractor powerplant is transmitted directly to the implement, resulted in greater mechanical simplicity and reduced the weight. Its introduction was of fundamental and determining importance in tractor design.

Major requirements in general-purpose tractor-design are: Adjustable ground-clearance, proper width of wheels and of wheel spacing and a short turning-radius.

Development in the tractor industry has led to important automotive-engineering progress. Citing instances of this, the author mentions the use of kerosene as fuel, the power starting of cold stiff engines, the employment of oil cooling-systems to meet extremes of low temperature, the induction of draft by the engine exhaust to increase the effect of cooling systems, the installation of air-cleaners, and the development of accessible unit-assembly construction.

THE complete engineering-development of the general-purpose tractor covers a period of from 30 to 40 years of effort. A survey of it takes us back to the time when the internal-combustion engine was undeveloped and little known as a power unit, and steam held undisputed sway as the prime motive-power. It will suffice, however, to cover this development briefly and learn from this background the real progress made to date.

The farm steam-power equipment of former days was developed to serve primarily as a portable belt-power unit, and was used almost entirely to operate heavy threshing machines. The incidental operation was that of self-propulsion and hauling the threshing machine and, perhaps, a water-tank wagon and a coal wagon in addition. More often, the necessary horses trailed behind drawing all the auxiliary equipment and, ordinarily, also a road wagon full of needed supplies, as well as odds and ends. Usually, the manpower could not be counted on the fingers of one hand. This slow-moving but picturesque troop was on its way early in the day. It fed off the land and "bunked" in the hay-mow. The "engineer" occasionally sounded a shrill whistle to mark his progress; he praised his powerful compound engine, its link motion and its governor to any one who showed interest; and he was the envy of the growing youth, to whom all others of the gang were inconsequential. Long before daylight, the engineer was at his post; and his engine was still steaming after dark.

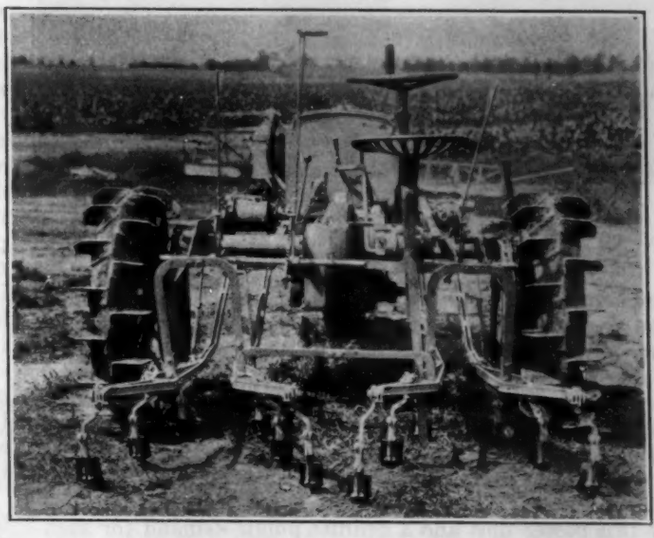


FIG. 1—AN EARLY TYPE OF CULTIVATOR AT THE REAR OF THE MACHINE

The Special Wheels Used in This Connection Are of Interest as Meeting the Requirements of Increased Area and Bite of Wheel with Increased Depth in Soft Soils. This Form of Wheel Construction Guards against Side-Thrust

The extension of tractor operations to the plowing field yielded a maze of troubles other than the usual leaky tubes and scaled boiler. The heavy outfits were unsuited to travel except over favorable roads. Their wanderings afield increased the number of mirings, of overturned units and of wrecked culverts and bridges, but these occurrences were taken as a matter of course; timbers, planks and posts were a part of the extra equipment needed to make the passage safe or to negotiate the mudholes. The prospective journey was preceded by an inspection of the route, and miles of extra travel was often required to assure safe arrival at a nearby point.

INTERNAL-COMBUSTION-ENGINE TRACTORS

The first of the successful tractors using internal-combustion engines appeared 20 years ago, was put into

[1] M.S.A.E.—Assistant to the manager of the engineering and experimental department, International Harvester Co., Chicago.

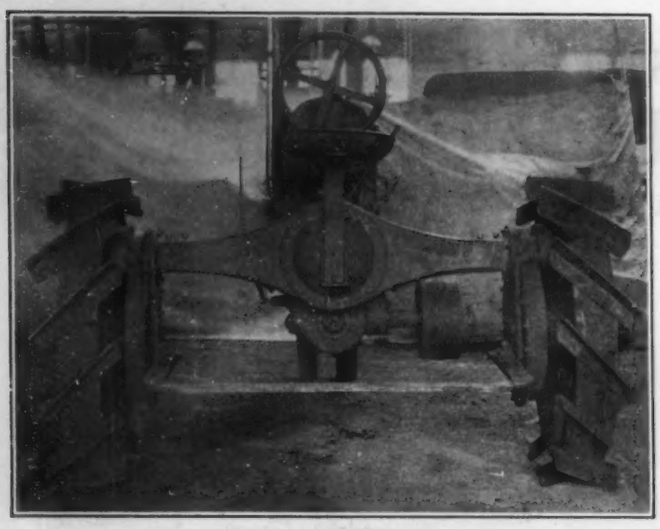


FIG. 2—REAR VIEW OF THE FARMALL
Note the 30-In. Clearance under the Rear Axle, Which Is Sufficient for Cultivating Corn, Cotton and Other Row-Crops

continuous production and made money for its builder. The design of this outfit started with the more definite purpose of meeting satisfactorily the two primary purposes of plowing and of supplying belt-power. Incidental operations were tried in the form of discing, harrowing and road hauling, but they were far from satisfactory owing to the passage of the 30,000-lb. power-outfits across plowed fields or pulverized soil.

The designers' anticipation of greater operating scope for this power unit and a definite public demand for such units turned the manufacturer to serious efforts toward the development of lighter machines. As a result, the 40,000-lb. steam-equipment, including the steamer and its trailers, and the 30,000-lb. gasoline power-unit gave way to units of 20,000 lb. Water and coal wagons were unnecessary, and the amount of manpower required was reduced. Essays into other field operations increased, even though the dread of packing the soil and of miring was a tremendous handicap. Genius was directed toward overcoming these faults by using better wheel-designs, more suitable lug proportions and larger areas of ground contact to reduce unit-area pressures.

For a long time, several of the old-line manufacturers of steam power-units could not be convinced of the future of explosion engines. Many never accepted the new motive-power and some surrendered unwillingly. Today, the demand for this steam type is very moderate, and that for gasoline power is increasing steadily. The rapid opening-up of the great Northwest, the plains of Canada and the grazing lands of the Southwest gave an impetus to the consideration of more suitable plowing units. Engineers flocked to the tractor industry from two main sources, the stationary-engine field and the automobile field. One group had its experience in heavy weights, generous proportions, large flywheels and slow engine-speeds; the other, in light-weight construction and high engine-speeds. Both groups of engineers were to a large extent inexperienced in fulfilling the agricultural requirements, and were feeling their way in tractor needs.

CONTROVERSIES OF THE DEVELOPMENT PERIOD

Conception at that time of what the general-purpose tractor should be varied radically. As a result, we witnessed the clash of ideas which favored types that had little in common. Those developed included the three and the four-wheel types, the crawler type, the combination wheel and crawler, the drum drive, the four-wheel drive, the cable system and the rotary plow. Each design had its staunch makers and users, supporters and advocates. Slow-speed heavy-units opposed the high-speed units in claims for efficiency, economy and suitability. Construction details found designers advocating gear, worm, friction and chain drives; engine types were horizontal, vertical or opposed; valve arrangements were supplied in the I-head, the T-head or the L-head types. Each was presented in a favorable light. Spring mounting was claimed to be better than rigid construction, and vice versa. Clutches of various kinds were incorporated. Plain, roller and ball bearings were employed. Live or dead axles were used. Steering arrangements and transmissions were of many types.

A hard-fought battle lasted for years over the relative advantages of operation on gasoline or on kerosene fuel, of hot-manifolds, short carbureter connections and varied devices for mechanically atomizing the fuel. Force-feed lubrication, splash lubrication and oil and grease-cup preferences were exploited. Arguments as to the relative merits of various oils arose constantly. Make-and-break ignition and spark-plug ignition were both favored; high-tension and low-tension magnetos were used. Cooling by oil, cooling by water, the use of a fan or of the exhaust gases to circulate the cooling air, and the use of a pump or a thermosiphon system to circulate the cooling medium, were questions for argument. On account of these radically different bases, the designs naturally varied as much as did the animals in Noah's ark.

The constructional differences were varied still further by ideas as to the proper capacity of the unit, thus giving the farmer a wide range of choice. Company vied with company for the farmers' patronage, and what might be termed the romantic period of tractor development began. The yearly contests at Winnipeg, Fremont and elsewhere served the purpose of settling many controversies over design, and helped to develop engineering skill and strategy. From the results of these trials, each group of salesmen raised claims from every conceivable

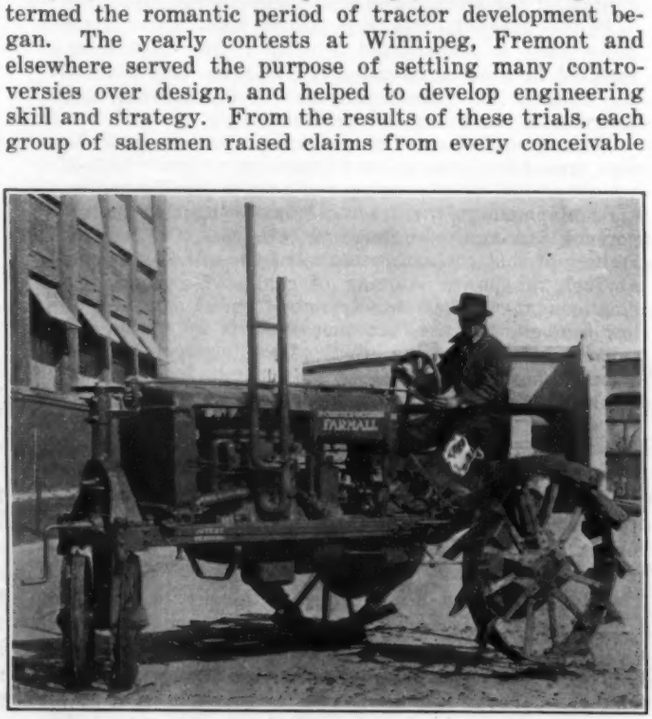


FIG. 3—VIEW OF THE FARMALL SHOWING ITS SMALL TURNING-RADIUS
It Is Possible To Turn This Machine in a 15-Ft. Circle, Which Is Advantageous in Cultivating Row Crops. If the Operator So Desires, He Can Make the Turn around Either One of the Two Drive-Wheels as a Pivot, This Result Being Accomplished Automatically by a Brake That Operates in Connection with the Steering-Wheel

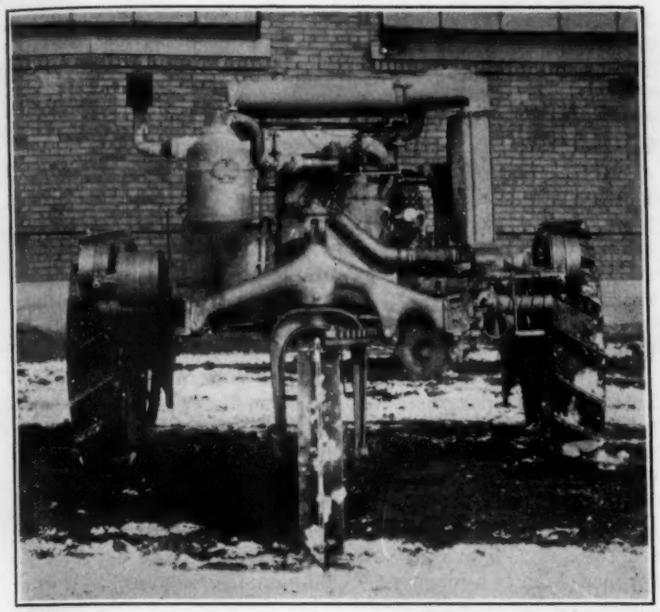


FIG. 4—FRONT VIEW OF THE CHAIN-DRIVEN TYPE

angle as to the superiority of its wares. The prospective purchasers were confused almost into indecision by rival claims and cautions. But, on the whole, these gatherings furthered the development. The impartial contest rules permitted the exchanging of ideas as to the demands or the requirements of the various units.

For years, the big machines were the pride of producer and user. They even rose to the dignity of having multiple engines that simultaneously plowed a strip 60 ft. in width, and covered 1 acre in less than 4 min. Innumerable contests and local tugs-of-war were held between these leviathans. Hitched rear to rear and surrounded by excited crowds, they smashed into the chains until one dragged the other to defeat and opened up a violent wordy contest of excuses and charges among the respective backers. But all this was necessary to the solution of the problem of development of the general-purpose tractor. The part played by field experts in those days must not be overlooked. Their work often was accompanied by days of anxiety or of triumph. These men, located at various points about the Country, were held in reserve; they were ready, with repair kits packed, to board the next train. Thus, real tractor service was developed. In this, as well as in competitive design and salesmanship, the reputation of the manufacturer was at stake.

These experts devised innumerable ways and means of extending the field operations of the tractors and increasing their usefulness. They performed many useful feats, such as removing stumps, hauling houses and removing trees, which helped to advertise the product and increase the interest and the attention of both actual and prospective purchasers. Likewise, the conditions served to indicate to the manufacturer the further requirements of the general-purpose tractor. The experts often made long and expensive trips in bitter cold weather, merely to fix a broken wire, to fill a gasoline tank or, in one case to remove maple syrup from the force-feed-lubricator piping. Like myself, many pioneers of this field could recount stories of the use of pacificism and of tact that were necessary to quiet irate owners who were too often utterly ignorant of electrical phenomena, bought cheap oils and feared to make adjustments or repairs.

TRACTOR SCHOOLS

Another vital element in the progress of the general-purpose tractor was that combined movement of the sales and the engineering departments, the winter tractor-schools. At these schools, for days and weeks, free instruction was, and is still being, given. Free use of the equipment, free instruction, free lunches and souvenirs attracted the farmers from afar. Here they learned in a systematic manner the fundamentals of engine construction, operation and care. They mingled with and exchanged ideas with their fellow men, and suggested possible improvements in the engines. They discussed with authority the variety of "best methods" of preparing land or handling crops in their respective sections of the Country. Hundreds listened attentively to the spell-binders who led these meetings. Occasionally, some member of the audience, dressed in a fur coat, slumbered for a time in spite of his serious interest, until perhaps a change in his center of gravity caused an unsteady folding-chair to collapse beneath him and aroused the crowd to hilarity and attention.

POWER TAKE-OFF

About 10 years ago, the efforts toward a general-purpose tractor centralized around the still lighter machine; but, to a large extent, its functions indicated a unit suitable for belt and drawbar work. The evident demand of the field required improvements in the attached units such as the tractor plow, the tractor binder, the tractor disc-harrow, the tractor mower and their several hitches. Other horse-drawn equipment was not completely suited to the more substantial power, the continuous operation and the higher speeds. Efforts at effecting one-man control over these combined units were meeting with success.

It became more and more clear that the delivering of power from the tractor to the drawn implement through

FIG. 5—PLOWING WITH TWO 14-IN. BOTTOMS
The Farmall Will Pull the Plows at a Speed of 3 M.P.H., under Average Soil Conditions, and Will Plow from 7 to 10 Acres per Day, Which Is the Equivalent of the Work Done by Three Men and Nine Horses

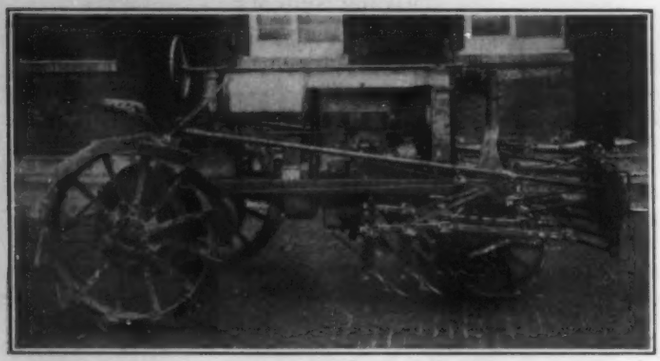


FIG. 6—FARMALL WITH A CULTIVATOR ATTACHMENT THAT CAN BE FREELY MANEUVERED FROM THE ENGINE SEAT

The Cultivator, Which Was Made Especially for Use with the Farmall, Can Be Easily Attached and Detached. The Guiding Is Done by the Steering-Wheel and Sufficient Space Is Provided under the Axle To Clear Growing Corn and Cotton as well as with the Ordinary Riding-Type

the ground was not logical or efficient; hence, the conception of the power take-off developed into a reality, and the redesigned attached machines were modified for this provision of taking power direct. This brought about a noticeable reduction in complexity and weight. This power take-off was one great step in advance.

CULTIVATION DEMANDS

While these auxiliary machines were enlarging the yearly time-period of usefulness of the tractor, the tractor was still unsuccessful in meeting requirements as a cultivating unit. On the basis of the statistics of the Department of Agriculture, we were not meeting the entire possibilities, as is shown by the following data:

In 1921, the area sowed to small grain was, in round figures, 120,000,000 acres, and that sowed to row crops was 150,000,000 acres. The comparative value of these crops harvested was roughly in the ratio of $1,600,000,000 to $3,900,000,000. This meant an excess of acreage in row crops over grain crops of 30,000,000 acres. The cultivation of these row-crop areas was left largely to horse and mule power. The average yearly use of the regular tractor, even after years of development, was found to be 50 working days of 10 hr. each, while the average requirements of tractor and horses ran the combined time total up to at least 100 such days; consequently, a radical change was desirable if this cultivation field was to be included.

The principal requirements next met were those of satisfactory clearance under the frames, proper wheel-spacing, narrow wheels and short turning-radius. Not until these were met could it be claimed that the general-purpose tractor was in sight.

THE GENERAL-PURPOSE TRACTOR

It is instructive to review what one firm has done to develop tractor equipment suitable for general purposes. While a good beginning was made about 1915, we may overlook the earliest endeavors and take up what was evident in 1918. Just as we have seen from the foregoing review that it took much time and attention and extensive experimental and development work to meet the earlier and simpler requirements, just so we find it necessary to go into protracted endeavor to perfect the refinements of the all-purpose tractor to meet the wider needs of today.

Fig. 1 shows an early type of tractor equipped with a cultivator at the rear of the machine. The special wheels used in this connection are of interest as meeting the requirements of increased area and bite of wheel, with increased depth in soft soils. This form of wheel construction guards against side-thrust.

In Fig. 2, a rear view of the Farmall tractor is shown. The 30-in. clearance under the rear axle should be noted; it is sufficient for cultivating corn, cotton and other row crops. In Fig. 3, the small turning-radius of this tractor is illustrated. It is possible to turn this machine in a 15-ft. circle, which is advantageous in cultivating row crops. If the operator so desires, he can make the turn around either one of the two drive-wheels as a pivot, this result being accomplished automatically by a brake that operates in connection with the steering-wheel. Fig. 4 is a front view of the chain-driven type of tractor.

Fig. 5 shows the operation of plowing with two 14-in. bottoms. The Farmall will pull the plows at a speed of 3 m.p.h., under average soil conditions, and will plow from 7 to 10 acres per day, which is the equivalent of the work done by three men and nine horses.

Fig. 6 shows the machine equipped with a cultivator attachment that can be freely maneuvered from the tractor seat. The cultivator, which was made especially for use with the machine, can be easily attached and detached. The guiding is done by the steering-wheel and sufficient space is provided under the axle to clear growing corn and cotton as well as with the ordinary riding-type.

Fig. 7 shows the cultivation of corn of good height. In this work the operator can see just what he is accomplishing, as all the work is done in front of him. Ample clearance is provided between the front and the rear wheels to prevent crowding the row, and the wheel spacing is such that turns can be made quickly and easily without running over the crops.

Fig. 8 illustrates the crawler type of drive used on a Farmall ensilage-cutter. An especially interesting feature of this tractor is the early use of radio equipment on a farm machine. This photograph was taken on June 27, 1919.

Fig. 9 shows a sweep-rake being driven by a tractor. The propelling power is supplied by the engine to the

FIG. 7—THE FARMALL CULTIVATING CORN OF GOOD HEIGHT

In This Work the Operator Can See Just What He Is Accomplishing, as All the Work Is Done in Front of Him. Ample Clearance Is Provided between the Front and the Rear Wheels To Prevent Crowding the Row and the Wheel Spacing Is Such That Turns Can Be Made Quickly and Easily without Running over the Crops

latticed wheels, which are an early type of construction.

Fig. 10 shows the latest type of Farmall drawing a tractor binder and shocker. The power take-off, driving through the slip-joint and the universal-joint, transmits engine power to operate the machines being drawn, thus relieving the carrier wheels of the load of picking up the operating power from the soil.

Engineering Features

This review would not be complete without some reference to outstanding contributions to automotive engineering made by this development. While the tractor was started by designers whose experience had been gained in the development of the stationary engine and the automobile, definite influences quickly caused differentiation. Even today, the tractor industry leads its allied automotive industries in certain important details such as making use of kerosene to reduce fuel costs. The starting of a cold, stiff engine by hand inspired the idea that resulted in the use of a magneto and the impulse

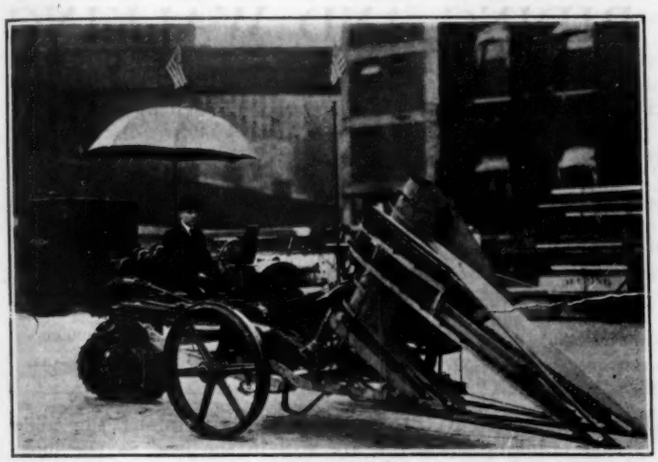


Fig. 8—Crawler Type of Drive Used on a Field Ensilage-Cutter
An Especially Interesting Feature of This Tractor Is the Early Use of Radio Equipment on a Farm Machine. This Photograph Was Taken on June 27, 1919

starter. Much work with the tractor in cold weather and in the far North led to a necessary overcoming of the freezing of the cooling system. One excellent and successful development was the use of oil in the cooling system; while this adds considerable weight, it still has undoubted advantages.

Fan-belt troubles and the complexity of the arrangement for tightening the belt led to the use of the engine exhaust to induce draft through the cooling device. The desirability of uniform engine temperatures under variable loads led to the adoption on many tractors of the thermosiphon system, with its maintenance of steady boiling-water temperature. Working in excessive dust and dirt developed the design feature of complete enclosure and the need for a solution of the problem of cleaning the air that passes into the engine. Excessive wear of cylinders and pistons before the use of air-cleaners became general called for the improvement known as the removable cylinder-sleeve.

Breakdowns far from home and in the field developed the need for systems of quick and easy field-repair. The accessible unit-construction was therefore developed to a degree not known even today in the best automobile practice. The crawler type of drive found extension and successful use in the battle tanks that were prominent in the World War. Generous and dependable proportions now govern the successful design, and every sensible technical advantage in the choice of materials, in shop practice, in standardization and in operation has been incorporated in the best tractors now built.

Fig. 9—Sweep-Rake Being Driven by a Tractor
The Propelling Power Is Supplied by the Engine to the Latticed Wheels, Which Are an Early Type of Construction

Summary

This paper endeavors to picture the phases in the development of the general-purpose tractor, to show some of the influencing factors and to give some conception of the time required in such a huge development. From the few simple and original prominent uses, efforts brought about extension to numerous complicated needs. The general-purpose tractor represents an achievement of engineering that has proved a very useful factor in the industrial and agricultural economic life of our Country.

All are aware what the handicaps of such a development are. Most of the equipment, as a whole, is seasonal; the opportunities for perfection in the individual uses are seasonal; the field requirements are extremely severe and variable; the agricultural equipment will bear only a nominal return to the manufacturer; and the equipment must be dependable and must work when it is expected to work to earn its own living. These points require clean, safe and strong engineering. The engineer who attacks this problem must use supreme judgment in compromising the variables and choosing the bases. Wide experience alone renders him safe in these judgments.

What originally started, roughly speaking, as a 20,000-lb. gasoline power-unit now is found to weigh about 3300 lb. The original translation speed was less than 2 m.p.h. The speed is now 3 m.p.h. or more. The earlier avail-

Fig. 10—The Latest Type of Farmall Drawing a Tractor Binder and Shocker
The Power Take-Off Driving through the Slip Joint and the Universal-Joint Transmits Engine Power To Operate the Machine Being Drawn, Thus Relieving the Carrier Wheels of the Load of Picking Up the Operating Power from the Soil

able engine ranged around 60 hp. The present engine has about 25 hp. The manpower needed has been cut to the minimum. In former practice, a licensed engineer was employed to operate the power unit; but, today, a youth 15 years of age handles with ease the more complicated outfit. The investment for the operating equipment is now but little more than one-third of what it was; the yearly time-total of possible operation on successful projects is 100 days and more, instead of 40 days; the weight per horsepower is easily one-half of what it was; and the cost per horsepower, in spite of increased values of materials and labor, is less by a safe margin. Further, an infinitely better design and a decidedly better list of materials are exemplified. The cost per pound is about one-half of what it was 15 years ago. The fuel cost of operating an outfit of this kind, based on 1921 data, is about one-half the yearly feed cost of the horses performing identically the same operations.

As has been noted, the builders have cooperated extensively with the user. They have gone to him with their tractor schools and given to him generously of their time and instruction. Further, they have established excellent repair-service. They cooperated with the State of Nebraska to unify the rating and merit of their equipment.

With the millions of dollars already spent in perfecting the equipment according to the ideals and under the handicaps stated, and with the definite engineering accomplishments noted herein, it goes without saying that the farmer, when fully aware of this effort and its results, will take advantage of his opportunities and motorize his farm to a greater extent than ever before. His financial condition alone prevents this now. We hope that this situation will soon be improved.

COMPARATIVE RISK OF RIDING AND WALKING

THE accompanying tables have been published by the Affiliated Aetna Companies as giving a possible clue to the relative safety of the man in the car and the man on foot. In Table 1 the chief dangers in motoring are analyzed and Table 2 presents statistics relating to claims paid by Aetna Life Insurance Co. under its accident policies for accidents to pedestrians caused by automobiles in the years 1914 to 1923, inclusive.

From an examination of Table 1 it appears that accidents in which the occupants were either thrown from their cars or overturned in them had been the cause of the greatest number of death and disability claims and consequently constitute the most serious menace. Out of the 214 fatalities 101, calling for the payment of $938,416, occurred in this way. Collisions accounted for 86 deaths, showing that this method of terminating an automobile ride is only a little less fatal. Another point of interest about the table is that cranking accidents are still in the lead as the most prolific cause of disability claims. Much has been printed of late to warn motorists of the danger of carbon monoxide that is given off in the exhaust gases of automobile engines. When carbon monoxide is allowed to collect in a closed garage it often causes asphyxiation. The danger has not been exaggerated and motorists should continue to be warned of this insidious menace.

Table 2 shows that under its accident policies the Aetna Life Insurance Co. has paid a total of 1294 claims in the 10 years, 1914 to 1923, inclusive, for accidental injuries to pedestrians caused by automobiles with a total indemnity of $185,591.31. In addition the Aetna paid a total of $218,645.00 for 25 fatal accidents, making an aggregate of 1319 accident claims with total payments amounting to $404,236.31.—*Economic World.*

TABLE 1—ANALYSIS AS TO CAUSES OF 13,930 CLAIMS PAID FOR ACCIDENTS TO AUTOMOBILE OCCUPANTS, 1914 TO 1924

Cause	For Indemnity and Death: Claims	For Indemnity and Death: Amount	For Death Only: Claims	For Death Only: Amount
Cranking	3,712	$328,834.81	4	$9,750.00
Collision	2,590	917,281.19	86	576,251.48
Boarding or Alighting	1,517	131,294.58	1	400.00
Thrown against Car or Seat	599	56,440.12	3	10,750.00
Thrown from Car or Overturned	1,822	1,160,095.46	101	938,416.73
Asphyxiation	12	103,216.28	8	103,000.00
Repairing Machinery	1,311	100,639.61	5	26,132.25
Miscellaneous	2,187	202,979.61	5	49,721.48
Burns or Scalds	180	10,094.53	1	1,500.00
Total	13,930	$3,010,876.19	214	$1,715,922.04

TABLE 2—CLAIMS PAID BY THE ÆTNA LIFE INSURANCE CO. FOR ACCIDENTS TO PEDESTRIANS CAUSED BY AUTOMOBILES, 1914 TO 1924

Year	For Disability: Claims	For Disability: Amount	For Death: Claims	For Death: Amount
1914	75	$7,665.94	4	$18,700.00
1915	95	10,225.55	..	.....
1916	91	11,426.16	..	.....
1917	127	11,078.03	..	.....
1918	103	11,587.83	4	25,095.00
1919	127	16,041.86	..	.....
1920	135	19,986.82	..	.....
1921	185	26,712.61	4	27,000.00
1922	165	32,738.53	3	12,850.00
1923	191	38,127.98	10	135,000.00
Total	1,294	$185,591.31	25	$218,645.00

PROGRESS OF CIVIL AVIATION

WITH one exception, each year completed since British civil aviation was inaugurated in May, 1919, has shown steady increases in the number of flights made, the mileage covered, the passengers carried and the goods transported, and there appears to be every likelihood that the rate of progress will be accelerated.

In analyzing the causes of involuntary landings in respect to flights made by the subsidized British firms during the year recently completed, the report shows that, of a total of 4033 flights commenced, only 351, or 9 per cent, were interrupted. The interruptions were mainly due to weather conditions, which were responsible for 213, or 61 per cent, of the forced landings, while engine or installation failures accounted for 91, or 26 per cent, of the stoppages; 47 landings, 13 per cent of the total, were due to other causes. In practically all cases, these forced landings did not result in any injury to the passengers or crew, but they are nevertheless important, since some risk is always present in landing on unsuitable ground and in conditions of bad visibility. Actually, with the exception of one fatal accident that occurred on an established air-route, no person carried in aircraft registered in the British Isles and flying for hire or reward was injured to any serious extent during the year covered by the report.—*Engineering* (London).

Street and Highway Safety

National Conference Formulates Comprehensive Recommendations

Traffic Regulation, Highway Construction, Motor-Vehicle Design and Maintenance and Cooperative Methods Discussed

THE report that was formulated at the National Conference on Street and Highway Safety, held in the City of Washington last month, is given below in nearly complete form. The subjects treated are of obvious importance and demand careful attention. The action of the Conference, which of course was based almost entirely on the work of the eight committees constituting it, deserves close study and application and should be very helpful.

In the report, it is stated that the growing toll of street and highway accidents has become a great National problem, reaching in 1923 a total of 22,600 deaths, 678,000 serious personal injuries and $600,000,000 economic loss; an increase of 80 per cent in the last 7 years. About 85 per cent of those accidents were incident to automobile traffic.

This is a National loss of so appalling a character as to warrant the most complete consideration and effort at drastic remedy. Such treatment is also essential in order that the full public benefit from this new system of transportation shall not be jeopardized because of accidents and congestion.

The Conference on Street and Highway Safety, including police officials, highway and motor-vehicle commissioners, insurance companies, railroad and street-railway companies, safety councils, chambers of commerce, labor unions, women's clubs, automobile associations, automobile manufacturers and various other national groups, was called by the Secretary of Commerce to determine the essential facts and promote better organization and coordination of activities in the reduction of accidents.

During the last 6 months eight representative committees have been engaged in the investigation of the facts of current practice and the most successful methods of reducing accidents. Their investigations cover (*a*) statistics, (*b*) traffic control, (*c*) construction and engineering, (*d*) city planning and zoning, (*e*) insurance, (*f*) education, (*g*) the motor vehicle, and (*h*) public relations. The reports of these committees, after widespread distribution and public comment, have been given detailed consideration by this Conference. They contain recommendations on which essential agreement has been reached and which, if carried out, even in part, will effect an immediate reduction in the accident toll.

The chief problem to which the Conference has addressed itself has, therefore, been that of putting this knowledge to practical application in the most expeditious manner.

The problem is primarily one of organization, which must rest upon a sound basis of legislation. It requires: first, proper facilities which, by promoting a free and even flow of traffic, will reduce at the same time the accident hazard and the extent of regulation required; second, a thoroughly considered and effectively enforced system of traffic regulation; and, third, a comprehensive program of cooperative action by all elements of society to promote the development of proper facilities, effective regulation and widespread education.

Uniform, impartial enforcement of reasonable requirements by adequate and properly organized police is a primary necessity in reducing street and highway accidents. Furthermore, the most abundant provision of adequate streets and highways, the most careful working out of traffic regulations and the most vigorous enforcement of traffic laws, to be 100-per cent effective in the reduction of accidents, must be supplemented by a sense of personal responsibility instilled in every motorist and every pedestrian.

The Conference recognized the need for fundamental preventive measures involved in comprehensive city planning and zoning. Unless proper control of the development of private property is exercised, it is rarely possible to provide street and highway facilities adequate for future needs.

The Conference submitted the following expression of its findings and conclusions which it recommends to the legislative and administrative authorities, to associations and business concerns, and to the motor-vehicle driver and the pedestrian.

Legislative Principles

The tendency is, in the opinion of the Conference, to include far too much detail in legislation. This not only divides responsibility but also hinders progress toward uniformity. Laws should be so drafted as to include only those features that must be authorized by legislation, leaving the great mass of detailed regulations to be prescribed by the responsible officials whose orders should, within the limits fixed by statute, have the effect of law.

There should be a minimum of restrictive laws and regulations, for the history of transportation shows that restrictive measures written without regard to economic needs have always proved a failure. The system of regulation should take into account and go hand-in-hand with a constructive program for meeting the demands of street and highway traffic.

The Federal Government's relation to the safety program is one of encouragement, of the assembly and the distribution of information and the development and the use of best practices, believing that uniformity will be secured by voluntary action of the various States.

The State, as the sovereign political unit to which cities and other political subdivisions are subordinate, should enact constructive legislation; including enabling acts that will empower cities and other local units to provide for a proper development of their territory; legislation dealing with unorganized areas; and laws creating a State department or bureau to administer the laws applying to motor vehicles, including the issuing and revocation of licenses for both cars and drivers and also the enforcement of regulations on the highway. This may be either a separate department or a division of some existing State department. The motor-vehicle department or bureau should have an adequate staff qualified by training and experience not only to handle licenses but to examine drivers, regulate traffic on the highways, investigate accidents and enforce regulations regarding the design, the construction, the inspection and the maintenance of motor vehicles.

Regulatory legislation should be for adoption by States and not by cities. The State enforcement division must have sufficiently broad powers to formulate the regulatory provisions necessary to the detailed control of traffic, leaving, however, to municipal authorities the formulation and the enforcement of all ordinances covering local conditions, such as the establishment of parking areas.

There should be an adequately manned traffic division in the police department with traffic safety a major function of such bureau. In cities the common practice of enforcement by the police department is recognized, and the police should enforce the State law within the city limits.

Traffic Planning

In all States and municipalities specific provision should be made for adequate and timely planning of traffic facilities and traffic-control measures. These activities should be closely coordinated nationally, between adjoining States, between States and their political subdivisions, and between the several agencies charged with the provision of facilities and control of their use.

In metropolitan areas faced with highly complicated traffic movement, it is desirable that a special traffic-planning commission be established whose duty shall be to study the flow of traffic, make recommendations as to the elimination of hindrances to this flow, formulate plans for the correction of unsatisfactory and unsafe traffic conditions and the like. It may be desirable for this commission to be a division of a city-planning body.

Grade Crossings

Elimination of grade crossings, either by the relocation of the highways or the rail lines or by grade separation, constitutes the only perfect solution of the grade-crossing problem. It should be carried on under a proper program, first eliminating the most dangerous crossings on thoroughfares carrying heavy traffic. This is made difficult by the enormous costs involved, and, if attempted on a wholesale scale, would impose an excessive financial burden resting in the last analysis upon the public. It is, therefore, necessary that the program, having due regard to the relative costs and advantages of grade-crossing elimination and other methods of protection, be given the most thorough joint consideration by proper authorities. In laying out new highways, the question of locating them so as to avoid railroad grade-crossings to the greatest possible extent should be carefully considered.

Relocation of highways offers many possibilities not yet fully developed which should be worked out by the State authorities, in cooperation with the railroads. Authority to order grade separations or proper protection at grade crossings should be vested in the State commission having jurisdiction over the railroads, which should also determine and enforce a proper division of the costs between the railroads and the public. The State highway department should have the authority to plan the improvements and to initiate the proceedings for all highways under its jurisdiction. Time is an essential element and a prompt decision should be provided for in the law.

Properly designated State commissions should be empowered to designate dangerous grade-crossings at which motorists must stop.

The elimination and protection of grade-crossings are of such importance and involve to such an extent the public safety as to require that priority be given to them, in the allocation of capital funds by the railroads, and of public moneys for highway building, over expenditures for other safety measures designed to protect the public.

Traffic Courts

Special traffic-courts, both city and rural, should be established for the prompt and effective handling of traffic violations. It is to the public interest that there be State supervision of local procedure in traffic-violation punishment, to the extent necessary to secure uniformity of administration and to prevent the abuse of judicial authority.

No unlicensed person should be permitted to operate a motor vehicle. A reasonable length of time after the passage of the law requiring operators to be licensed should be granted operators already qualified in which to secure licenses without examination. The department or division administering the motor-vehicle law should have full authority to refuse an operator's license to any person and to suspend or revoke a license already issued for any reason deemed sufficient.

Before granting an operator's license, the department or division should determine the applicant's ability to operate a motor vehicle safely by ascertaining his physical and mental fitness and his knowledge of the laws, and by requiring an actual demonstration of his ability to operate a motor vehicle. It is recommended that all States designate the minimum age limit, but that no person under 16 years of age, and no person who cannot read English, should be permitted to operate, drive or direct a motor vehicle.

Reckless driving and any other flagrant disregard of the rights of others by any user of the streets or highways should be vigorously and unceasingly prosecuted. There should be legislation providing adequate penalties for infractions of traffic rules, including mandatory revocation of licenses for a specified length of time for cumulative evidence of carelessness or irresponsibility, for operating a motor vehicle while under the influence of intoxicating liquor or drugs, or for other serious offenses against the motor-vehicle law, and severe penalties for driving during the period of suspension or revocation. There should be a sufficient number of organized traffic officers to detect and prosecute such infractions; and there should be cooperation between States for the enforcement of the laws in each State.

The law with respect to motor vehicles should provide that when any motor vehicle is operated with gross negligence or recklessness, in violation of the provisions of the general motor-vehicle law, resulting in serious injury to persons or property, where such violation has been established by due process of law, the registration of the car should be suspended or revoked and its number plates be removed or other means of prohibiting any use of the vehicle instituted for a period depending on the seriousness of the offense.

Speed

Regulation of speed of vehicles should be directed primarily at reckless driving and should be uniform throughout the Country so far as practicable. It should be unlawful to operate a vehicle at a speed greater than is reasonable and proper, having regard for the traffic and the use of the highway, or so as to endanger the life, limb, or property of any person.

To promote uniformity the speed limits should be subject to general control by State law, which should prohibit any municipality from establishing a speed limit lower than 15 m.p.h., provided that municipalities and other political subdivisions of the State should be empowered to fit speed-limit zones according to local conditions, but should be required to mark the boundaries of such zones plainly.

In rural areas, instead of an absolute speed-limit, it should be provided that when any vehicle exceeds 35 m.p.h. that speed shall be prima facie unreasonable, and it should be incumbent upon the operator to prove affirmatively the reasonableness of such greater speed.

Certification of Titles

All of the States should adopt the principle of certification and registration of automobile titles as one of the most important and effective means for reducing thefts, and, by virtue of this result, owing to the causal relation between the theft and accident hazards, also a measure for improving the present public accident situation. This legislation should be uniform and contain adequate provision for enforcement with proper penalties for violation. Closer cooperation between the various agencies interested in the passage of these laws would be helpful in securing their enactment.

Reporting and Investigation of Accidents

Where they do not now exist, statutes should be passed in every State which would make it the specific business of some State agency, preferably that clothed with authority for issuing or revoking licenses, to receive traffic-accident reports and to investigate all accidents, irrespective of

whether they occurred within or beyond the corporate limits of municipalities.

It should be made obligatory by law for those concerned to report traffic accidents involving serious personal injury or property damage, and an adequate penalty for failure to report should be provided. Such reports to be tabulated and distributed at regular intervals by a State agency to the courts and to the officials responsible for the enforcement of the traffic regulations.

Safety Education in Schools and Provision of Playgrounds

Education in safety and accident prevention should be incorporated in the curricula of elementary schools, both public and private, parochial schools, night schools, vocational schools, citizenship schools and schools for non-English-speaking adults.

Adequate playgrounds throughout the community should be provided and particularly a playground should be available for every school, both as a safety measure to keep the children off the streets, and as a means for safety instruction and citizenship building. Special training in safety measures should be provided for playground supervisors. Like the schools, playgrounds should, so far as practicable, be so located that children will not have to cross busy traffic streets in going to and from them.

Provision of Traffic Facilities

The systematic provision of funds is essential to permit carrying on a well-ordered program for the improvement and maintenance of traffic facilities, including adequate roadways and rights-of-way, elimination of excessive grades and curves, guard rails or walls at danger-points, clear view at curves and intersections, the public's share of the expense of grade-crossing elimination and protection, roadway lighting, street and highway signs, signals and surface markings.

The legislative authority should grant power to make and enforce regulations and take other action indicated in the following paragraphs. These are not intended to be a complete or exhaustive enumeration of the regulations that should be prescribed, but cover the more important recommendations of the several committees.

Uniformity of Traffic Regulations

Uniformity of traffic regulations is essential. This varies from exact uniformity in the case of definitions of terms, rules of the road, signs, signals and highway markings, and rules for passing railroad grade-crossings, to essential uniformity in such matters as reports of accidents, parking regulation, motor-vehicle design equipment, inspection and maintenance.

Accident Statistics and Reports

Statistics regarding street and highway accidents are so vital to any comprehensive understanding and treatment of the safety problem that their collection, publication and analysis in every State and community are essential. Their value depends largely upon prompt and frequent publication.

In the investigation of accidents, sufficiently detailed information should be gathered to indicate clearly whether the accidents occurred because of

(1) Recklessness, carelessness or incapacity of persons
(2) Fault of mechanism of the vehicle
(3) Physical conditions of the locality where the accident occurred

The information that should be obtained may be grouped under the following headings:

(1) Location
(2) Time (hour)
(3) Type
(4) Weather
(5) Road conditions
(6) Lighting conditions (street)
(7) Physical conditions of persons involved
(8) Experience of driver
(9) Age and sex of driver
(10) Relation of driver to owner
(11) Condition of car or cars at time of accident
(12) Speed of car or cars
(13) Primary cause of accident
(14) Violation of traffic ordinances or motor-vehicle laws
(15) Age and sex of injured
(16) Extent of injuries
(17) Estimate of property damage
(18) Preventive action recommended

Accident-spot maps should be maintained, to be used primarily to detect those points at which accidents occur most frequently, and as a basis for plans to eliminate the conditions that cause accidents.

Traffic Surveys

Special regulations for the use of particular streets, including the placing of automatic signs and signals, the designation of arterial streets and highways, and restrictions of class of traffic, direction of traffic, parking privileges and the hours and periods of such restrictions, should be based upon competent traffic-counts and analyses and established in accordance with some general plan of traffic movement founded upon the design of the street system in each city.

In congested centers and where large volumes of vehicle movement take place between centers considerably removed, it is suggested that an effort be made to segregate streetcars, motor trucks and passenger automobiles on separate thoroughfares, and that attention be given to the desirability of restricting the unnecessary use of residence streets by through motor-truck traffic.

City Planning and Zoning

Street and highway hazards are due chiefly to vehicular traffic. Those hazards can be greatly reduced by a proper arrangement of streets and highways. Consequently, each community must study and carefully consider its own special problems with particular emphasis upon

(1) The problems presented by streets and highways crossing each other at grade or crossing railroad or rapid-transit lines at grade, with the two purposes of reducing the number of crossings by a better arrangement of transit lines and thoroughfares and by separating grades so far as practicable where crossings remain necessary. Elimination of grade crossings is most needed along major-traffic arteries or boulevards

(2) The problem of classifying traffic and of providing suitable and adequate facilities for each class. This involves the proper location of the various kinds of development, industrial, commercial and residential, through a proper planning of traffic and other public facilities provided in the various areas, supplemented by zoning regulation of private property

(3) The location of its traffic-originating centers and the possible development of its outlying areas with the two purposes of straightening main-traffic arteries and of so spacing them that there will lie between them areas sufficient in size to support neighborhood stores, schools and recreation facilities

(4) The possibilities offered by its topography and its present development to create by-pass highways and belt highways that will permit through-traffic, especially trucks, to avoid congested districts or even any built-up portions of the city or town

(5) The control of subdivisions to avoid in the future

the types of street that tend to congest traffic and cause accidents

Stopping and Day-Storage Space for Automobiles.—Each community should reach a decision, based upon present local conditions and probable future development, as to how it will provide for the stopping and parking or day storage of automobiles, and should apply that decision in its city plan.

Design and Equipment of Streets.—While the arrangement of streets and parking spaces is the first essential in securing an even and safe flow of traffic, this must be supplemented for each kind of street by determining the most effective width, corner radius, sight clearance and the like, and the needed equipment, such as safety zones or isles of safety, lighting devices, traffic signals and pavement marking. These will differ with the character of the street and the width of its roadway.

Importance of Subcenters and Satellites.—It is necessary for each region or group of communities to plan more carefully the development of industrial and business subcenters and satellite communities, with a view both to encouraging appropriate decentralization and preventing these new centers from becoming in turn areas of traffic congestion and danger.

Relation Between Street Facilities and Development of Private Property.—Each community should, in determining the character, width and arrangement of its streets, at the same time determine, through zoning, the character, use and bulk of abutting buildings. Each community or group of communities in planning the main arterial-highway system should take account of the effect of zoning regulations in regulating and stabilizing traffic flow.

Inter-Relation of Traffic Facilities.—Each community should, in planning its traffic system, bear in mind that the automobile and the motorbus supplement rather than conflict with rapid-transit rail-lines.

In order that a community may deal effectively with its problems of street and highway safety, it must coordinate all its efforts in a comprehensive traffic and thoroughfare plan, showing a complete system of traffic ways, parking or automobile storage areas and needed street improvements both within the city or town limits and within the area of probable building development outside such limits. The traffic and thoroughfare plan should be developed in consonance with a plan for the transportation and transit lines and stations and with the zoning regulations. The adoption of these plans should be followed by a definite long-term improvement and financial program.

Street and Highway Construction

Every pavement in a city street should be wide enough for at least three lanes of traffic without street-cars or four lanes with street-cars. Streets for heavy traffic should be wider. Street and highway pavement-widths should be in multiples of widths of traffic lanes; that is, 9 ft. minimum for motor vehicles and 10 ft. for street-cars.

Right-of-way for parking space, for clear view at curves and intersections and for future roadway widening should be provided before the cost of the land becomes prohibitive. Parkways and sidewalks should be placed so as to facilitate future widening with proper provision for safety zones.

To make it feasible to prohibit parking or stopping on the traveled roadway, improved rural highways should be provided, either continuously or at intervals not exceeding 300 ft., with reasonably hard and level parking-places entirely outside of the traveled way. It is generally not practicable to construct city streets and pavements of sufficient width to provide permanently for unrestricted parking.

Safety, as well as economy, requires that grades in excess of 6 per cent be avoided where feasible, in laying out or improving thoroughfares of primary importance, in country, village or city.

Highways of primary importance should not have curves of less than 300-ft. radius. Heavy grades and sharp curves should not be combined.

The cross-section of the pavement or roadway should be as flat as drainage conditions will permit. Curves should be widened and banked and provided with transition curves to effect an easy transition between straight sections of the roadway and the curves.

Guard railings of substantial type should be erected on the shoulders of embankments.

A clear view of approaching vehicles for at least 300 ft. should be provided at all points on highways of primary importance. This may necessitate controlling private advertising signs, upon the public highways or private property near the highways, removing trees, shrubs and sloping banks on or off the right-of-way at curves and intersections, and cutting down sharp hill-crests.

At street intersections the grades of each street should be maintained if possible, particularly those of main arteries of traffic. The radius of curvature of curbs should ordinarily be not less than 15 ft., and 20 ft. in special cases.

Every bridge on an improved highway or street should be at least 22 ft. wide, to enable two lines of traffic to pass without difficulty. Existing one-way bridges should be widened or rebuilt. Suitable provisions should be made for the safety of pedestrians, either by sidewalks or by frequent safety-zones built outward so as not to narrow the roadway.

Detours around highways, streets or bridges under construction or reconstruction should be carefully selected and maintained in safe condition, and clearly marked.

Safety requires that pavements and roadway shoulders be maintained in good condition. This will include the prompt removal of snow from all streets and highways of heavy traffic. In congested areas, street repairs and street openings should so far as possible be carried out at the periods of minimum traffic.

Marking Speed Zones.—Local speed-limits and other special regulations should be conspicuously announced by standard signs at appropriate places on the highways, indicating the beginning and the end of speed zones.

Signs and Signals.—Cautionary or stop signs and signals at danger-points, direction and distance signs at important junctions and intersections, and signs and signals to indicate special traffic-rules and regulations are all necessary for the safe operation of vehicles on the streets and highways. For signs and signals, both luminous and non-luminous, the following color indications are recommended, and these colors should not be used for any other purpose: Red for "Stop"; green for "Proceed"; yellow for "Caution," as at curves. Special cautionary indications are needed at cross-roads. White letters or symbols should be used on red or green background, and black on yellow. Distance and direction signs should be black and white. The use of imitation traffic-signs for advertising purposes should be prohibited. Besides highway intersections, for which a special color is recommended, sharp curves, steep descending grades and narrow bridges or places in the roadway are danger-points, and should be conspicuously marked with yellow cautionary signs. Red stop-signs should be used at the entrances to through-traffic highways.

Railroad-Crossing Protection.—Railroad crossings remaining at grade should be safeguarded in every reasonable way. Standard warning-signs and pavement-markings should be used to mark the approach to all public railroad crossings. Where the volume of traffic requires it, additional protection should be afforded by the use of flagmen, gates, or approved electric or mechanical devices. Sharp curves, abrupt changes of grade, roughness in the pavement, or other conditions at or near the tracks which tend to divert the attention of the motorist, should be avoided. The spotting of cars near unprotected crossings by railroads should not be permitted.

Street and Highway Surface-Markings.—Rural highways should be marked with a white center-line on curves, at and near hill-crests, at irregular intersections, and at any other points where safety requires that motorists keep strictly to the right. No parking, even off the traveled roadway, should be permitted opposite these white lines. White center-lines should not be used on straight level sections of highway or street except at highway, street or railroad crossings. Black center-lines on straight sections of highways are desirable. Pedestrian lanes should be marked on the pavement at busy

intersections. Objects near the roadway, such as curbs, poles, fences and rock surfaces, should be painted white. Obstructions, such as columns and curbs, at the center of underpasses, should be striped diagonally white and black.

Lighting.—City streets should be sufficiently illuminated so that bright headlights will be unnecessary and so that traffic signs will be clearly visible. Flood-lighting of traffic officers is recommended. Lights should be provided on State highways wherever the State finds this financially practicable.

The Motor Vehicle

Brakes.—Pending the adoption by constituted authorities of a code for standard braking-ability, all motor vehicles, except possibly motorcycles and heavy trucks, should be capable by means of the service brake alone of stopping in a distance of not more than 50 ft. from a speed of 20 m.p.h. on a dry, smooth, hard-surfaced road free from any loose material. The emergency brake should be capable of the same performance as that specified for the service brake, but as the absolutely minimum requirement it should be capable of holding the vehicle on any grade which it can ascend.

Steering-Gear.—Lost motion or play in steering-gears should be limited to about 15 deg. The toe-in of front wheels should never exceed ⅛ in.

Lights.—Present lighting regulations should be more rigidly enforced as a necessary beginning in arriving at any improved night-driving condition on the highways. The study of proper road illumination, combined with the minimizing of undesirable glare, should be given immediate further consideration with a view to determining whether it may not be possible to improve the regulations now in force.

Clear red should be used for tail-lights and the rear aspect of parking-lights, and its use should be prohibited for any other exterior light so located as possibly to be mistaken for a tail-light or a parking-light. Clear yellow should be used for "stop-lights." The maximum permissible intensity of such "stop-lights" should be established. The use of colored lights on vehicles tending in any way to confuse the meaning of the customary safety-lights should be prohibited.

The location of spot-lights should be limited to the right of the vertical center-line of the vehicle and the beam of the spot-light should never be directed to the left of the vertical center-line.

Driver Vision.—Design of bodies and cabs should be carried out with due regard to the necessity of reducing to the minimum the shut-off area of driver vision. The use of all posters or other obstructions to vision on the front windows or on the windshield should be avoided.

Audible Signals.—All motor vehicles should be equipped with adequate audible signals.

Motor-Vehicle Width.—The overall width of body chassis and load of any motor vehicle should be limited to 96 in.

Motor-Vehicle Inspection and Maintenance

Loading beyond the rated capacity of any vehicle should be prohibited. In the interest not only of safety but of economy of operation, adequate periodic inspection, adjustment and repair of motor vehicles are absolutely essential. To this end a simple and practical inspection-chart and code, applicable to all makes of motor vehicles and giving particular attention to items affecting safety should be prepared. To promote its general acceptance, it is recommended that this chart and code, when prepared, be issued by the Department of Commerce.

Public-service commissions and other public bodies having control of common-carriers operating motor vehicles should establish reports and methods of supervision to ensure adequate inspection and upkeep.

Conduct of Drivers and Pedestrians

Pedestrians and motorists should bear a considerate attitude each to the other. Along rural highways, wherever suitable sidewalks or paths are available pedestrians should use them. Where none are available, they can generally walk most safely on the left-hand side facing the traffic, but should not force motor traffic out of line or otherwise impede it. In cities, pedestrians should be instructed, urged and required to keep within the boundaries of designated safety-zones and crossing-places and, when there is congestion, to cross only with the traffic. Motorists should be required to accord pedestrians safe and dignified use of such safety-zones and crossing-places.

In city streets, except one-way streets, and on rural highways whenever the traffic is heavy, the current of traffic should be on the right-hand side of the roadway. Heavy and slow-moving vehicles should keep to the right where possible, and their operators should, by mirrors or otherwise, keep a good lookout to the rear so as not to obstruct traffic.

Vehicles, before entering or crossing a properly designated "through-traffic" street or highway, should be required to come to a full stop. At all other intersections any approaching vehicle should be required to grant the right-of-way to any vehicle approaching from its right at such speed as to reach the intersection at approximately the same time.

Except in wide city streets carrying two or more well-defined lines of traffic in the same direction, a vehicle should pass another moving in the same direction only on the left-hand side of the overtaken vehicle, and only after giving due warning of approach. Overtaking moving vehicles on sharp curves, approaching hill-crests, at intersections or at railroad crossings should be prohibited. An overtaken car should not increase its speed while being overtaken, and the operator of an overtaking car should exercise care not to crowd from the highway the car being overtaken. Street-cars stopped to discharge or receive passengers should not be overtaken except where a safety zone or loading platform is provided.

Parking and Stopping.—Standing cars should not be permitted to endanger or impede seriously moving traffic, or to prevent reasonable access to the sidewalk for loading or unloading of vehicles. This will prohibit the parking or the stopping of cars on any part of the traveled portion of a rural highway and also involves the prohibition or vigorous restriction of parking at congested points in cities.

Hand-Signals.—Safety requires that operators of motor vehicles indicate by hand-signals their intent to do anything that may affect the movements of others in the vicinity. Uniformity and simplicity in such signals are both highly important. A single cautionary signal, made by extendng the arm well outside the vehicle, as a warning that the operator is about to turn, slow-down, stop or back, is recommended as preferable to a code that attempts to show more exactly what the operator intends to do. Vehicles the design of which does not permit the driver to make proper hand-driving signals should be equipped with some simple form of mechanical signal to give the necessary indication.

Railroad Grade-Crossings.—Unless a full-stop is required by law, vehicles should not be permitted to exceed a speed of 15 m.p.h. when approaching within 100 ft. of any railroad crossing. A penalty should be enforced against a motorist who disobeys a clearly visible and positive signal to stop at a grade crossing.

Tires.—The use of badly worn tires, especially on the front wheels of a motor vehicle, should be avoided as a possible source of danger.

Traffic-Control Officers

Standardized plans should be developed for the selection and the training of traffic-control officers, and such plans should be put into operation by all communities. It is further recommended that, for the benefit of small communities, either such training be organized on a State basis or arrangements made by which the opportunities of the larger cities can be made available to the smaller communities.

Education

Education in safety and accident prevention should be incorporated in the curriculum of elementary schools by such means as the following:

(1) As part of a general course in citizenship, in

which due regard shall be paid to the responsibilities and obligations involved in human relations. For this purpose, through some agency of research, materials and accounts of practices in the teaching of safety should be gathered together for use in the preparation of such a program

(2) As subject matter of other courses in such fundamentals as arithmetic, geography, history, reading, nature studies and art

(3) Through educational contests

(4) Through organized school-boy patrols and junior safety-councils

(5) Through the use of motion pictures and dramatization

(6) Through talks by local-traffic police-officers in uniform

Safety education should be carried into the secondary schools, in which the habits and attitudes inculcated in the elementary schools should be extended into higher and more complex fields.

Desirable Features of Automobile Construction

Automobile manufacturers are urged to give attention to the following suggestions:

The engine accelerator pedal should be located at a sufficient distance from the brake pedal to minimize the danger of applying the accelerator when intending to actuate the foot brake. The brake pedal should be so constructed as to minimize the danger of the driver's foot slipping from it when he wishes to actuate the foot brake. In vehicles in which it is intended that the accelerator pedal and the brake pedal shall be operated by the same foot, the movement of the foot from the accelerator to the brake pedal should be as easy and direct as possible.

Motor vehicles should be so designed as to permit braking with the engine on severe grades without injury to any of the mechanical parts. Service brakes should be so constructed as to be capable of simple and safe adjustment by the operator throughout the life of the wearing parts. Ratchets of hand brakes should be so designed and constructed as to have greater durability and certainty of operation, so that they may give efficient service throughout the life of the vehicle. The design and construction of motor vehicles should be such that unintended lubrication shall not reach the braking surfaces.

Some device for cleaning the windshield from rain and snow that can be conveniently operated by the driver should be available for use when windshields cannot be kept open or a clear vision secured by other means. The portion of the windshield in front of the driver should be made so it can be readily opened by the driver if weather conditions require it to afford proper vision.

The question of mirror design and location for purposes of rear view should be studied.

A study of the use of bumpers as a safety device should be undertaken in the near future. When bumpers are used, the height of the center-line above the road surface should be standardized so far as conditions will permit.

Organization of Cooperative Work

The conclusions of the Conference on Street and Highway Safety should be brought to the attention of the political heads of communities of 5000 population or less on main traveled highways with the recommendation that they be put into effect insofar as they are applicable to communities of this size.

With regard to communities of from 5000 to 25,000 population a complete set of the Conference Committee reports should be brought to the attention of the political head of the community and to the attention of the Chamber of Commerce, or, in the absence of a Chamber of Commerce, of some corresponding civic body, with the same recommendation.

With regard to communities of from 25,000 to 100,000 population, where no safety organization is in existence, steps should be taken where practicable immediately after the Conference to bring about the formation of voluntary safety-committees of which the nucleus should be such representatives of the various cooperating organizations as may be located in the community, with a permanent secretary on either part or full time. These committees should organize the community to put into effect the conclusions of the Conference and to consider the continuation of an organized safety program. In many cities of this class one or more organizations with safety programs already exist, even though there may be no safety organizations as such. In such cases these organizations should be utilized to initiate the formation of the proposed voluntary safety committees to carry out the recommendations of the Conference and eventually effect a permanent safety organization.

With regard to cities of 100,000 population or more, where no safety organization is in existence, steps should be taken immediately to bring about the formation of a permanent organization to cooperate with the proper public authorities in the promotion of safety and in making effective the conclusions of the Conference.

Program of Future Activities

Considerable overlapping and duplication in the field of safety education, publicity, and the collection and dissemination of data exist. Such duplication is inevitable in connection with a subject so close to the public interest. It is especially desirable, however, that as much duplication as possible be avoided in the efforts of unofficial organizations that are more particularly concerned in the National field. Their combined facilities utilized in the furtherance of the conclusions of the Conference on Street and Highway Safety will contribute immeasurably toward attaining a common objective, increased safety on street and highway.

The first step in this direction has been taken with the calling of the Conference on Street and Highway Safety. There should be a continuation of these cooperative steps. This can best be accomplished through a joint committee consisting of representatives of the cooperating organizations to be appointed by the Secretary of Commerce for the purpose of coordinating the safety programs of National organizations and of carrying to a conclusion the recommendations of the Conference on Street and Highway Safety.

It is not desirable to set up a new permanent National safety organization. However, the cooperation of the various organizations in this effort to find a solution of the traffic problem must be carried to completion in such a way as to assure productive results. This can be done only through the medium of a joint committee of their representatives, meeting periodically and conducting without interruption a steady drive through the local agencies provided for in the recommendations.

It is also recognized that the further development of certain special phases of the problem before this Conference is extremely desirable, and to that end voluntary committees of technical experts should be created.

Perhaps most prominent among these special phases is the problem of securing uniformity of legislation, regulation, statistics and practices. The flow of street and highway traffic recognizes no political boundaries, and cannot be hampered by changing principles of control, even though local conditions may dictate the necessity for local changes of detail, without creating that confusion and uncertainty which is in itself a menace to the safety of motorist and pedestrian alike.

With regard to one phase of the problem, the physical relationship of size, weight and speed of the vehicle to the highway, great progress has already been made by the cooperative efforts of the Bureau of Public Roads, the highway officials and the manufacturers of the vehicles. On other phases tending toward the standardization of the rules of conduct, considerable progress has been made by

(*Concluded on p. 72*)

The Economic Aspect of Tooling for Interchangeable Production

By JOSEPH LANNEN[1]

PRODUCTION MEETING PAPER *Illustrated with* DIAGRAMS

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

ABSTRACT

WHEN the volume and the variety of the parts produced by a plant increase beyond the point at which the shop mechanic is capable of devising the methods and building the tools for accomplishing the desired results, it becomes necessary to make a division of labor, and a special department on tool division is needed to determine the proper sequence of operations and the suitable equipment to produce the required quantity with the required degree of accuracy. It is necessary that the men be informed regarding the daily and the ultimate numbers of parts to be produced and the tolerances that will be allowed.

The foremost consideration of the production engineer should be economy of production. In this phase of tool engineering, the ultimate number of parts to be produced plays an important role and equipment should be selected that will give the maximum production. All known methods of production should be compared and the most economical one chosen. Rules are given for governing economic tooling and an illustrative problem is worked out for the production of bearing-caps. By means of charts, calculations are made to determine the comparative economy of drilling holes in 100,000 bearing-caps by the use of single-spindle vertical drilling-machines, of single-spindle vertical drilling-machines equipped with four-spindle multiple drill-heads, and of multiple-spindle vertical drilling-machines.

Having determined the economical method of selecting equipment, the tools must be produced economically. This involves accurate knowledge of the result to be accomplished, care in the preparation of the preliminary drawings, and the avoiding of unnecessarily difficult pattern-work and unnecessary machining operations. As the principal value of a tool estimate is the paying of bonuses in the toolroom, the group-bonus wage-payment plan employed by the Paige-Detroit Motor Car Co. is described.

IN spite of the opportunities for increased production that have been created by specialized tooling, it is surprising how little attention is being paid to the economies that are possible in this class of work. When a relatively small volume and variety of parts is being produced, the shop mechanic is capable of devising methods and of building tools that will accomplish the desired results but, as the volume and the variety increase, the details connected with the work grow until it becomes necessary to make a division of labor. It is at this point that the methods and equipment department and the tool division have their inception, and the more skilled and ingenious of the mechanics are placed in charge of them. But it is possible for these same mechanics to defeat the purpose for which they are working, if they do not understand and apply the economic principles governing the work.

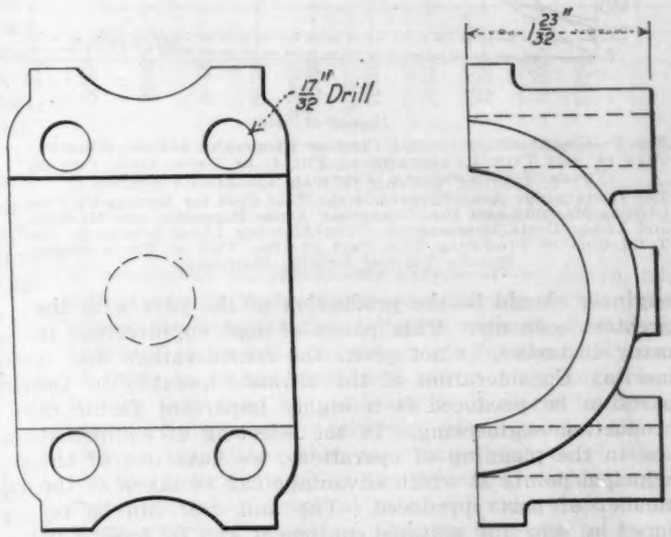


FIG. 1—TYPICAL PART ANALYZED FOR MOST ECONOMICAL METHOD OF PRODUCTION

The Four 17/32-In. Holes Can Be Drilled on One or More Single-Spindle Vertical Drilling-Machines, on These Machines Equipped with a Four-Spindle Multiple Drill-Head, or on a Multiple-Spindle Vertical Drilling-Machine

When the methods and equipment department and the tool divisions are created, a change takes place in the manufacturing procedure. Instead of the shop's devising its own methods and building the necessary tools, the new work is given to men who determine the proper sequence of operations and the necessary amount of suitable equipment for producing the required quantity of parts with the required degree of accuracy.

QUANTITY AND TOLERANCES

To carry out this work in an intelligent manner, it is necessary for these men to be informed of two things: (*a*) the daily and, as nearly as can be estimated, the ultimate number of parts to be produced, and (*b*) the degree of accuracy that is to be required in each part.

An estimate of the volume of production is furnished by the management; the accuracy is determined by the engineering department, and this information is conveyed through tolerances on the drawings. With this information at hand, the men are ready to proceed with the work. The manufacturing equipment should be planned in such a way that it will be just good enough so that the amount of money spent for equipment, plus the labor cost, will represent the lowest possible production cost.

In selecting the proper equipment and choosing the most suitable sequence of operations for producing a new part, the foremost consideration of the production

[1] Tool and equipment engineer, Paige-Detroit Motor Car Co., Detroit.

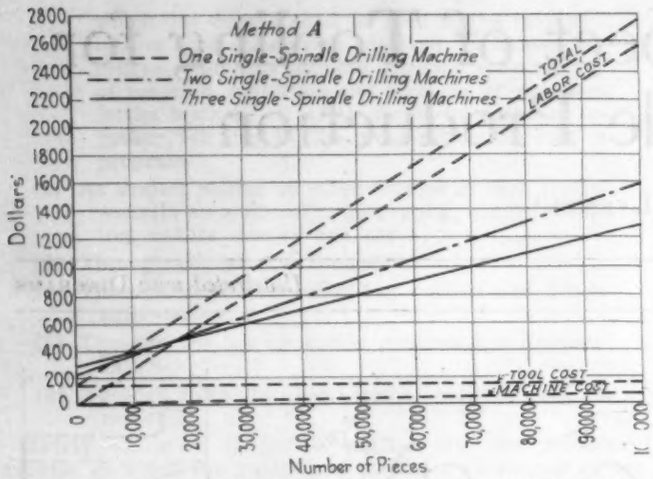


FIG. 2—CHART SHOWING THE COST OF PRODUCING 100,000 BEARING-CAPS OF THE TYPE ILLUSTRATED IN FIG. 1, BY USING ONE, TWO OR THREE SINGLE-SPINDLE VERTICAL DRILLING-MACHINES

The Rectangular Area Represents the Tool Cost for Setting-Up One Drilling-Machine and the Triangular Areas Represent the Machine and Labor Costs Respectively. The Slanting Lines Represent the Total Cost of Producing This Part on One, Two or Three Single-Spindle Vertical Drilling-Machines

engineer should be the production of the part with the greatest economy. This phase of tool engineering, in many instances, is not given the consideration that it merits. Consideration of the ultimate quantity of the parts to be produced is a highly important factor in production engineering. In the selecting of equipment and in the planning of operations, we have one of the principal points at which advantage can be taken of the number of parts produced. The unit cost can be reduced by selecting suitable equipment and by tooling to secure the maximum production.

It is evident that, in order to select the most economical method of performing a machine operation, it is necessary to know and to be able to compare all the known methods that could be applied to the problem at hand. It is our purpose to organize and to classify the known means and methods of performing a machine operation and to select the ones that are the most economical.

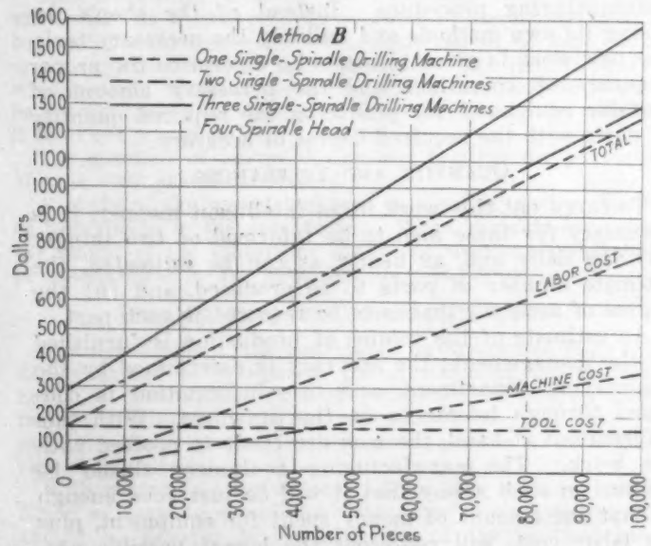


FIG. 3—COST OF PRODUCING 100,000 BEARING-CAPS ON ONE OR MORE SINGLE-SPINDLE VERTICAL DRILLING-MACHINES EQUIPPED WITH MULTIPLE DRILL-HEADS

The Same Arrangement of Lines Is Used Here as in Fig. 2 and It Is Found That One Vertical Drilling-Machine Equipped with a Four-Spindle Head Is More Economical than Two or Three of These Machines with Similar Equipment

The production engineer is thus able to work with the methods that he thinks are worthy of consideration and to compare their relative economic values.

RULES FOR ECONOMICAL TOOLING

The following are some of the rules that govern economical tooling for production:

(1) The full capacity of the machine must be utilized
(2) Idle men and idle machine-time must be reduced to the minimum
(3) The work must be clamped and released in the shortest possible time, except when the length of the loading process is limited by the speed of the machine.
(4) The cutting process must be completed within the shortest possible spindle or table travel
(5) Daily production must be maintained

The following problem will serve to illustrate the methods employed in determining the correct equipment and the proper layout of tools to produce a given number of parts with the greatest economy. In Fig. 1 is shown a bearing-tap. We will analyze the operation of drilling four 17/32-in. holes in order to determine the most economical method of producing this part. This operation can be performed on one or more single-spindle vertical drilling-machines, on one or more single-spindle vertical drilling-machines equipped with four-spindle multiple drill-heads, or on multiple-spindle vertical drilling-machines.

DRILLING OF BEARING-CAPS

The chart reproduced in Fig. 2 shows the cost of producing 100,000 bearing-caps by using one, two or three single-spindle vertical drilling-machines. The rectangular area represents the tool cost of setting-up one machine; the triangular areas are the machine and the labor costs, respectively. The upper dotted line represents the total cost of producing this part on one single-spindle vertical drilling-machine. The dot-and-dash line represents the total cost when two machines are used. The total is worked out, as described, for one drilling-machine. The full line is the total cost of machining, when three single-spindle machines are used. This is the maximum number of machines that could be taken care of by one operator and, therefore, is the limiting feature of this method.

The next method to receive consideration is the use of one or more single-spindle vertical drilling-machines equipped with multiple drill-heads. The chart is reproduced in Fig. 3. The tool, machine and labor costs have been compiled as in Fig. 2. The figures show that one drilling-machine equipped with a four-spindle head will produce 100,000 parts with greater economy than will either two or three of these machines with similar equipment.

We will now look into the efficiency of a multiple-spindle vertical drilling-machine for this work. The chart reproduced in Fig. 4 shows the cost of drilling 100,000 pieces with a multiple-spindle vertical drilling-machine equipped with one, two, three and four jigs, the jigs being loaded while the machine is idle and all parts being loaded so as to be drilled simultaneously. The figures on the chart show that three jigs will give the required production with the greatest economy.

Fig. 5 compares the most efficient methods determined by the three previous charts and, as a result, shows that method *C*, in which is used a 12-spindle vertical drilling-machine equipped with three jigs, is the most economical method of producing the stated quantity of bearing-caps.

If the calculations just described are used in conjunction with the rules governing economical tooling for production, a great saving can be effected in the production costs of duplicate parts. The method of procedure employed in the foregoing analysis may appear to be long, but, in actual practice, when the production engineer has become familiar with the method, it is possible to arrive at the correct result without going so deeply into detail.

Tool Production

Having once determined the economical method of selecting equipment, we must see to it that the tools are produced with economy. In the designing of tools, it is especially desirable that we should know what we are about before we begin the drawings. To produce drawings of tools economically it is necessary that a sketch, embodying the essential features of the tool that is wanted, be made at the outset. This sketch should be complete enough to enable the estimater to figure roughly the cost of the tool, if that cost should be required by the tool engineer. The tool designer can effect a saving in the cost of tooling by avoiding difficult machining operations and unnecessarily close tolerances in the construction of jigs and fixtures, and by avoiding corework on patterns, wherever possible.

If proper attention is given in the drafting-room to the methods of producing the patterns, much unnecessary cost can be avoided in their construction. When the drawing of a tool has been completed, the cost of producing it should be estimated. This estimate will prove useful in many ways. It will serve as a check on the preliminary estimate made by the engineer, which,

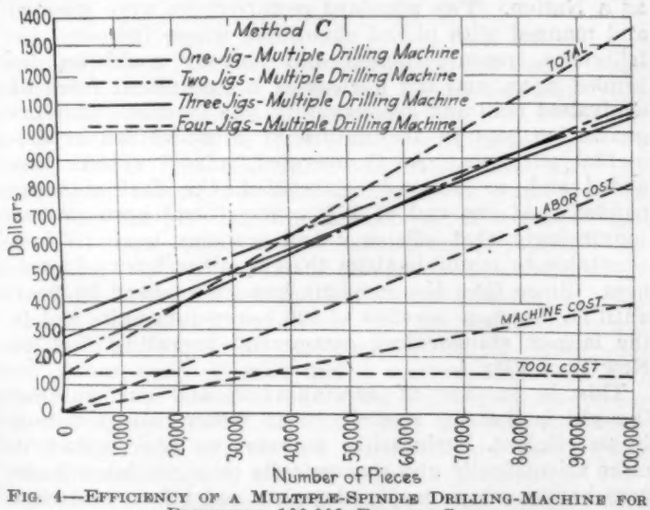


Fig. 4—Efficiency of a Multiple-Spindle Drilling-Machine for Producing 100,000 Bearing-Caps

In This Case the Machine Was Equipped with One, Two, Three and Four Jigs, Which Are To Be Loaded While the Machine Is Idle, All Loaded Parts Being Drilled Simultaneously. Three Jigs Will Give the Required Production with the Maximum Economy

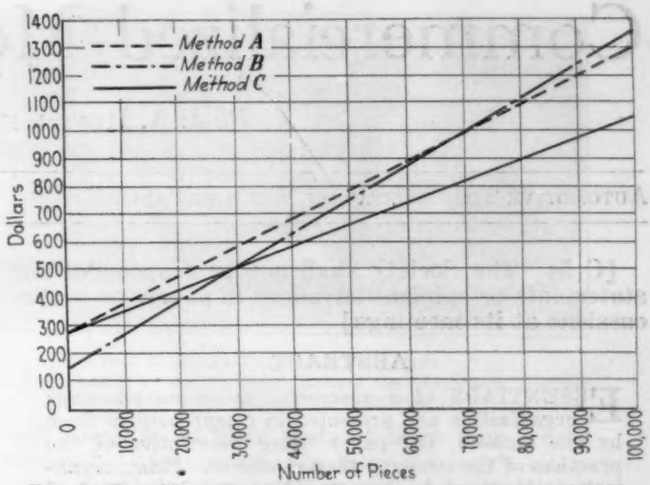


Fig. 5—The Most Efficient Method of Producing 100,000 Bearing-Caps

This Chart Compares the Most Efficient Methods of Production as Determined in Figs. 2, 3 and 4 and Shows That a 12-Spindle Vertical Drilling-Machine Equipped with Three Jigs Is the Most Economical Method

on account of the incomplete nature of the sketch, might not possess a high degree of accuracy. The tool engineer can compare this estimate with the cost that he had used in working out the charts for the total number of parts to be produced, and can make changes in the line-up that may be necessary to conform to the estimate. Unnecessarily difficult patternwork, and machining operations that may have been overlooked by the designer, show up in the process of estimating, and the estimater, a practical man, will take steps to avoid them wherever possible. Changes are not to be made promiscuously, however, for at times the cost of altering a completed drawing may equal or be greater than the possible saving to be effected by making a change. The principal value of a tool estimate is that it can be used as a basis for paying bonuses in the toolroom.

Group-Bonus Wage-Payment

The following group-bonus wage-payment plan, based on the tool estimate, has been employed by the Paige-Detroit Motor Car Co. with good results. All work that comes into the toolroom is estimated, and the number of hours estimated for each job is forwarded to the time department. At the end of each pay-period, the estimated times on the jobs completed during that period are totaled, and from these times is subtracted the total time turned in on the job, 50 per cent of the difference being prorated among the toolmakers according to their earnings during the pay-period. This form of bonus requires very little additional clerical work, promotes teamwork among the toolmakers, and assures that the finished cost of tools will average lower than the predetermined cost.

WAGES AND AUTOMOBILE PRICES IN GERMANY

WHILE the ratio of wages paid by German and American automobile manufacturers, respectively, is one to six, the ratio of prices asked for relative products is three to one. In other words, the German workingman receives one-sixth of the wages of the American workingman performing the same kind of labor and the German consumer has to pay three times more for a similar car than does the American consumer.—F. E. Junge.

Commercialized Motor-Truck Haulage

By J. A. Hoffman[1] and W. F. Banks[2]

Automotive Transportation Meeting Paper *Illustrated with* Photographs

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

ESSENTIALS of a successful motor-truck-haulage organization are presented in comprehensive form by the authors, the paper being descriptive of the practices of the company they represent. Plant, organization, kinds of haulage business and how obtained are included in the description. Divisions of the business, such as the movement of commodities from the docks, of import consignments, of merchandise on long-distance and day-haulage bases, of package and other special services, are mentioned, the last being so-called contract work in which large fleets of motor vehicles are furnished to, and operated for, customers. The appeal for patronage is made on the basis of service and economy. Estimates are submitted when soliciting contracts and quotations of cost for the proposed service are based upon a thorough knowledge of the service required which has been obtained after a detailed investigation. Other features of the service include "surplus" and pick-up work and the furnishing of individual trucks and the consequent reduction of idle truck-time for small businesses. Heavy insurance against public liability is carried.

Service is the only thing the haulage company has to sell. Its equipment consists of motor vehicles, garages, garage equipment and maintenance facilities. The different types of vehicle and the use of sectional protective tarpaulins and other special equipment are illustrated. Different types of van and "stake"-body trucks, tractor-trailer and armored-cab vehicles are included. The tendency is to use a body 8 ft. wide.

Features of the garages include doors 14 ft. wide, floor space free from columns, large floor-area, interior curbs on each side against which to back the rear wheels of trucks and thus stop the vehicle before the rear end can hit the wall, pilot lights for ordinary use and flood lights for emergencies.

The necessity for having a thorough plan of maintenance in such a business is emphasized. Its basis is standardization. The spare-unit-replacement plan is used. Inspection is very systematic and competent, by men who have had previous experience on equipment of a similar type. A reserve truck is sent out when a vehicle breaks down on the road. Time records of every operation are kept very accurately. "Delay" is considered the most important word on a driver's report, and he knows it. The repair shop has adequate appliances, including a traveling crane; and a rigid routine-system is maintained in it.

Control has for its basis a proper cost-system, completely in accord with the general accounting system. The operating organization consists of a superintendent, a dispatcher, competent foremen and drivers, all of whom have been selected carefully, well trained and encouraged by considerate treatment to render conscientious service. Thus, the best service possible under any given set of conditions is made available to each customer.

IT became apparent not many years ago that one of the weak links in our vehicular transportation system was the local pick-up, delivery and shipping service. Our streets were jammed with motor or horse-drawn vehicles of every description in every state of disrepair. Many of the trucks that congested the streets were empty, or partly loaded only, and many were duplicating the work of other trucks. Some were stalled by breakdown; others were halted to suit the drivers' convenience. Almost all were struggling in an orgy of waste, of lack of organization and of inefficiency. It was a comprehensive vision of this situation and the relief and economies to be effected by the concentration of a large volume of this business in the hands of one large operating company instead of many small units, that led, 10 years ago, to the establishment of our company.

As a basis, the organization had a small but efficient staff made up of trained engineers who were capable of treating business problems in a big way, and had the thought of introducing into the trucking field the same thorough-going American efficiency and business-like procedure that, in other lines, have made us preeminent as a Nation. Two standard motor-trucks were selected and manned with picked chauffeurs whose industry, intelligence, resourcefulness and honesty could be depended upon, and the nucleus of a mechanical force of equivalent skill and dependability was formed. This organization was in the nature of a model for experimental purposes. As it operated, a cost system was added and, as demands warranted, the fleet was expanded. At the end of 2½ years it had been proved convincingly that efficiency and economy were no less adaptable to motor haulage than to other lines of business. Since then the company has grown year by year until its fleet now consists of 120 heavy-duty units and is the largest standardized commercial operating fleet in New York City.

This is an age of specialization and our guiding thought is that, by specializing in motor transportation in an efficient, businesslike manner, we can conduct it more scientifically and economically than can large business houses whose major thoughts and efforts are concentrated on the production and marketing of their goods, with very little time left to devote to their haulage problems.

Plants and Equipment

Our plants and equipment consist of our general office, garage and service-station, located at the foot of Amity Street, Brooklyn, N. Y.; an auxiliary garage, located on Manhattan Island at 18th Street and Avenue A, New York City; 120 heavy-duty gasoline and electrically driven trucks; trailers; and cars for the use of executives, superintendents and foremen. We located in Brooklyn, instead of on Manhattan Island, because, in our business, the plant has to be on the ground floor and, since we require in excess of 55,000 sq. ft. of floor area, the land values are a governing factor. Other

[1] Vice-President of sales, Motor Haulage Co., Brooklyn, N. Y.
[2] Vice-President of operation, Motor Haulage Co., Brooklyn, N. Y.

locations were considered, but were discarded, the principal reasons being those of loss of economy on account of excessive dead-mileage, inaccessibility and lack of room for expansion. We located in the heart of the industrial section of Brooklyn, within easy access to both Manhattan and Staten Islands by the East River bridges and by ferries. Our main garage is in five separate sections. Four sections are used for garage purposes and one for service and maintenance.

Management

Success or failure, of any business, depends upon management. Until very recently, the trucking business was owned largely by men who started in as horse drivers or chauffeurs and, by hard and conscientious work, built up their business to their present standards. Such men are entitled to great credit but, naturally, they did not have the time or the opportunity to secure technical

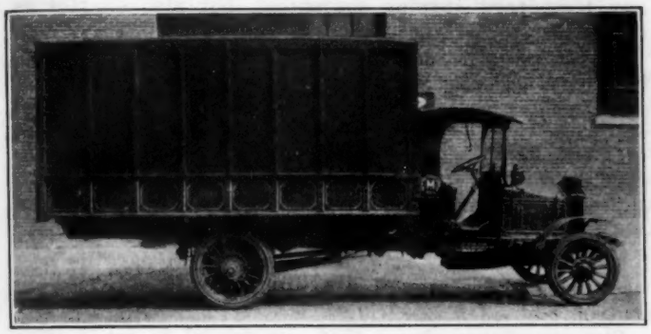


Fig. 1—Standard Form of Van
Used Chiefly for Handling Meat and Bakery and Other Products That the Elements May Damage Quickly

training in engineering, cost accounting and the theory of transportation; therefore, theirs are largely one-man organizations having obvious limitations.

Our business differs little from a large manufacturing business. We own valuable machinery and have our production problems in that each unit must be made to produce its maximum each day in the way of tonnage handled. We have our cost and accounting problems, and our transportation and traffic problems. If general business finds it best to use the best brains obtainable, why should motor transportation be an exception? Fortunately, the founder of our company, R. H. Matthiessen, was a business man and a trained engineer. He appreciated the value of education and surrounded himself with trained men from the start. Our company is officered today by experienced engineers and traffic men, who are supported by efficient accounting, operating and mechanical departments, each man and each department striving to do the work at the maximum of efficiency and economy.

Kinds of Business and How Obtained

Among our several different kinds of business, some are railroad and steamship transfer-freight, or through-bill-of-lading freight for transfer from railroad to railroad or between railroad and steamship; import freight; long-distance, inter-city hauling; surplus work, on the day basis or tonnage hauling for firms during periods when their freight runs in excess of the capacity of their own equipment; light-car package-delivery service; dump-truck work; lumber hauling; coal hauling; pick-up hauling of odd lots of one or more truckloads of freight; and contract work.

We specialize on contract work; that is, in the owner-

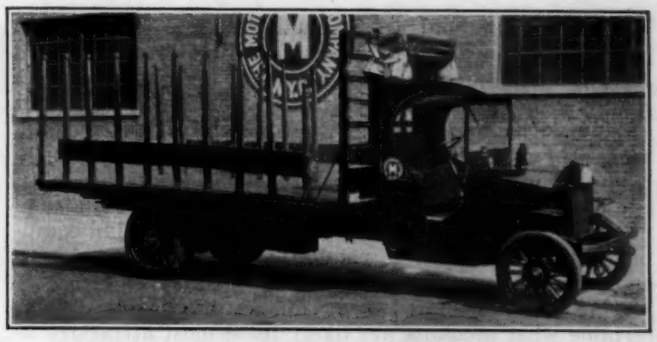


Fig. 2—Stake-Platform Body-Type
Stakes Are Spaced so as To Accommodate the Maximum Number of Standard-Size 53-Gal. Barrel

ship and operation of large fleets of heavy-duty trucks for responsible organizations, in their company's colors and carrying their company's names and advertising matter. Not only do we operate the trucks but, in many instances, our duties begin in the stockroom where the goods are packed. We take complete charge of the shipping facilities, the marking, the preparation of shipping papers and the classifying, handling and loading of freight aboard trucks. Thereby, we relieve the merchant or the manufacturer of all incidental petty details. In due course we deliver the bill of lading or the receipt, and that completes the transaction.

In many instances, we handle large portions of the complete cargoes of import steamers. The importer does not even see his freight. We receive a detailed book of instructions. Our operating department carefully inspects the consignments for loss or damage, the elimination of old markings and for remarking, makes direct truck-delivery of the local freight and reships the remainder to any part of the Country. The importer's only worry is in connection with the receipt of a clean bill of lading.

The securing and subsequent handling of work of this nature requires a most careful survey of all the available facts and a comprehensive cost-study. I say this for several reasons. First, with almost every new account, we are required to take over all of the existing motor-vehicle and horse-drawn equipment, garage and office leases, as well as the employes. This involves a cash outlay of many thousands of dollars. Second, our proposition, to be attractive, must show a saving over existing costs; therefore, the work has to be done on a very small margin of profit. Inasmuch as the contracts cover a minimum period of 3 years, and in many instances are made for 5 years, an error of 1 or 2 cents

Fig. 3—Rack-Body Truck
This Type Has a Slightly Sloping Body, a Panel Height of 30 In. and Is Equipped with Either Three or Four-Piece Tarpaulins. New Trucks of This Type Have a Door on Each Side

per 100 lb. in a contract rate will result in heavy losses. All this means that, in a business like ours, one must have: (*a*) an adequate cost-system, (*b*) traffic men who are thoroughly versed in transportation and in shipping, (*c*) a positive knowledge of what a certain type of equipment can do under certain conditions, (*d*) an organization that can carry on a comprehensive operation from the moment the work is taken over; and (*e*) the financial resources necessary for the taking-over of existing equipment and leases and the installation of new and improved equipment.

It is our first purpose, so far as practicable, to determine what accounts are likely to be most attractive to us. It then becomes the duty of our sales department to sell the idea of our service to the executives of the prospective customer. We make the appeal on the basis of service, cost and responsibility. We can do this because our standardized fleet and exclusive concentration on the problem of motor transportation make for efficiency and economy. Self-maintenance instead of service-station maintenance, bulk purchases in place of individual purchases and group supervision as against individual or entire lack of supervision all make for economy. Privately owned trucks have only one customer to serve and, when that customer's business is slack, the trucks are idle. Under our operation, Customer *A's* decreasing requirements are used to fill the surplus requirements of Customers *B*, *C* and *D*, This reduces idle truck time to the minimum.

When the idea is sold and rates are requested, the real work starts. We quote no rates without making a complete survey. Our sales organization includes experienced traffic and transportation men. One or more men are assigned and the investigation starts in the shipping and receiving departments in the morning when the whistle blows and continues through every phase of the operation. Voluminous data are collected of goods handled over given periods. Careful study is made of the equipment in use and of its performance; also of the possibility of economies to be effected by the use of other types of equipment, improved shipping and receiving methods and facilities, personnel, freight routing, truck routing and special deliveries. The data are carefully tabulated and submitted with a detailed report. Some of the principal items that are conspicuous in the report are:

(1) A complete description of the shipping and receiving facilities, emphasizing wherein they retard the movement of freight and the possible truck detentions liable to be incurred

(2) The shipping-room hours on week days and especially on Saturdays and holidays

(3) Lists of articles to be moved that state the weight, the style and the size of the containers, their value and their susceptibility to concealed loss and damage

(4) The zones where the freight is delivered or picked-up and whether it is to be received at or delivered to foreign or domestic transportation-lines, public warehouses or business houses

(5) Loading expenses at railroad and steamship piers and public warehouses

(6) Delivery schedules to be maintained on account of existing sales-policies

(7) Possible number of trips per truck per day

(8) Daily operating mileages

Feature (8) seems to be given very little consideration by most truck operators but, with us, it is one of the factors that receives the most careful study. The data are all boiled down to possible performance, our costs are applied and, in the final analysis, we know in fractions of units just what the cost of performing the work will be. In consequence, we are able to quote intelligently according to the service required.

When a deal is finally agreed upon, a contract is entered into. It sets forth in detail the exact work to be performed, the conditions under which it will be performed, the territory to be covered, the facilities and the services to be furnished by both parties, the rates for the different classes of service and equipment, the penalties for delays to equipment, our respective legal and moral responsibilities, the insurance carried and the like. After signing, an abstract of the contract is made. This becomes the working instructions for our operating department.

In addition to contract work, we aim to do a percentage of surplus and pick-up work. This not only utilizes any temporary surplus equipment, but also enables us to operate loaded, both ways, in many instances.

As an illustration of the organization necessary to take over a comprehensive operation on short notice, we cite the fact that we took over an account recently that required from 20 to 30 trucks per day, operating out of four different plants. We received word at 1.00 p. m. that the contract had been awarded to us and that we must take over the work at once. Between 3.00 and 5.00 p. m. on the same day the trucks and equipment were turned over to us. At 7.00 a. m. the next day the fleet was in full operation, with our own organization in control.

Our experience shows that our appeal to prospective clients is due to

(1) Excellence of reputation, primarily ascribable to the company's businesslike policies and the fact that it always lives up to its contracts and obligations

(2) Financial condition

(3) Modernness of plant

(4) Personnel of the management

(5) The thoroughness with which the company studies clients' problems before quoting rates and throughout the period of the contract

(6) Good mechanical condition and cleanness of equipment

(7) Insurance of clients against public liability damage to the extent of $40,000 per truck; against property damage up to $1,000; and merchandise insurance from $3,500 to $25,000 per truckload, according to requirements

Sales Resistance

Our sales resistance can be grouped mainly under two headings. First, lack of knowledge of the true cost of operation. Ignorance in this respect is very pronounced and is due largely to the fact that the head of the company in question does not personally delve into its trucking operation, but depends upon approximate cost figures compiled by a shipping department. These figures usually contain only the weekly out-of-pocket expense for chauffeurs' wages, gasoline, oil, tires and the like; the result is that the true cost is not represented. In many instances the formula for setting up the costs can be traced back to an over-zealous truck salesman. However, whenever we can arrange for a complete assembly of a company's true cost figures, we have no trouble in bettering its cost of operation.

Second, sales resistance comes from the party that buys a truck by paying some certain sum down and the balance in monthly installments. This kind of com-

FIG. 4—TYPE OF SEMI-TRAILER BODY
Used for Railroad-Freight Transfer-Work. It Has a 30-In. Panel, a 4-Ft. Side-Door and Is Equipped with a Three-Piece Tarpaulin

petition is one of the great drawbacks in our business. It has the effect of continuously destroying the market. The operator has to meet his monthly notes and is therefore forced to take work at any price that is offered. To my knowledge, one company that has daily use for a large number of trucks has used this kind of service for a number of years; it knows that it is paying less than the actual cost of operation, and that it is only a matter of time when the operator of that service will fail, but that, when he does, the company can find a new recruit to fill his place. This type of operator does not know his costs; he carries little or no insurance; and lives on his depreciation. We hope that in time manufacturers will discourage installment purchases of trucks and allow the used-truck market to take care of this class of buyer.

LESS-THAN-CARLOAD FREIGHT

The service we are performing for the account of the Long Island Railroad consists of handling the less-than-carload freight in the western terminal area and on the Port Washington and Whitestone branches, in motor trucks instead of in freight-cars. It is largely patterned after the service that is now in operation at approximately one-third of the stations on the Pennsylvania Railroad System, with modifications to meet the local conditions and the heavier tonnage movements on the Long Island Railroad. So far as the shipper and the consignee are concerned, no change is apparent; to all intents and purposes their freight is moved by rail, but what actually happens is that it moves by truck if it is short-haul freight and by rail and truck if it is long-haul freight.

In the western terminal area, one tractor and semi-trailer outfit has not only taken the place of approximately 18 daily merchandise cars, but has reduced the time of the freight in transit to 25 per cent of the rail time. It is our understanding that the truck service has shown a decrease in operating cost over that of the rail service, as well as a marked reduction in loss and damage claims. While these are facts worthy of serious consideration, we must not lose sight of the decided advantages to be gained by this carrier in reducing the car congestion in the crowded terminal areas.

In this connection, credit is due R. S. Hurd of the Pennsylvania Railroad System, for making it possible to install this service and to J. C. Evans, assistant chief

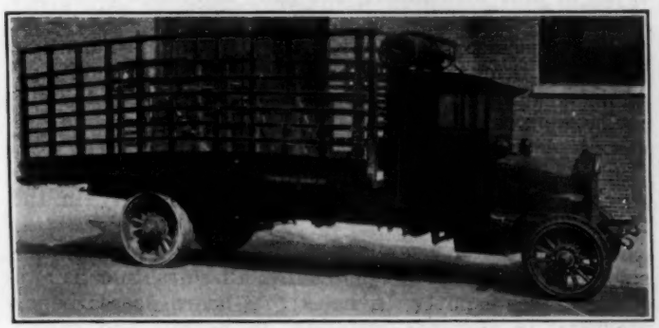


FIG. 5—ARMORED-CAB TYPE
Used for the Transport of Especially Valuable Commodities. The Cab Is of Bullet-Proof Steel, Has a Window Across the Front and a Small Window on Each Side

engineer of the Long Island Railroad, for his active cooperation in developing a workable plan of operation.

EQUIPMENT

We have nothing to sell but service. Consequently, our company is organized for service. Our productive machines, motor trucks, are great tributes to the combined engineering skill of automotive engineers, and we hope that, in our efforts to use them properly, we are providing greater scope for the application of their

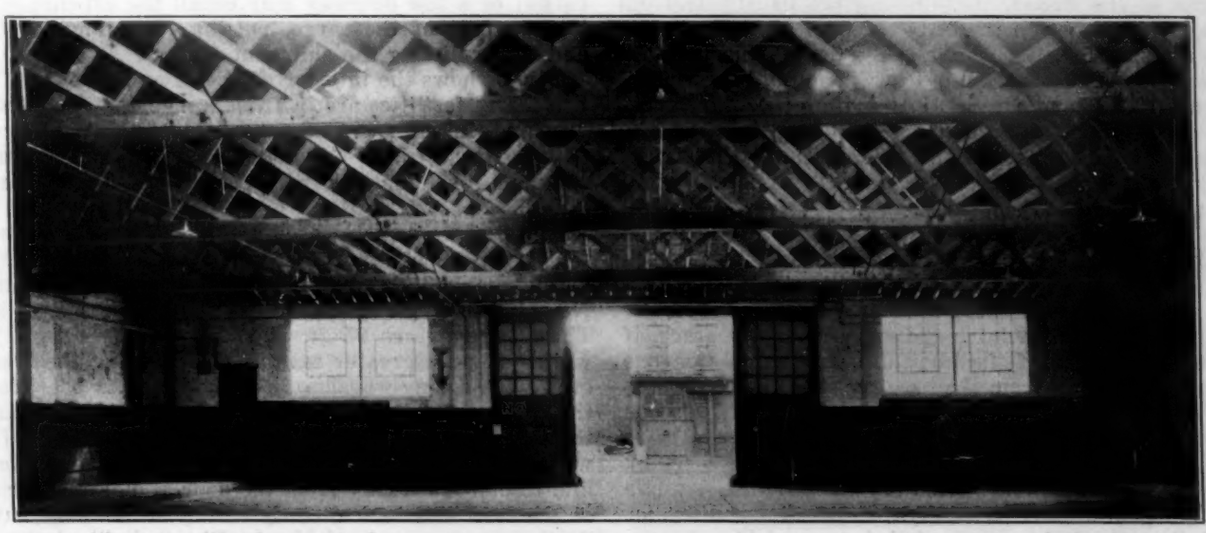


FIG. 6—GARAGE INTERIOR
Important Features Include an Adequate Doorway, Gasoline and Oil Facilities in Front, a Floor 95 x 100 Ft., a Curb or Bumper To Prevent Backing Against the Walls, Ample Skylights, Non-Extinguishable Pilot-Lights Except for Key-Control and Flood Lights for Emergency and One-Man Control

engineering abilities. Automotive products are expensive. They have a recognized economy due to production, but, to become profitable, the production must be constantly held at the maximum. To this end, we are directing our efforts, through the utilization of suitable equipment, competent men and adequate control, which, we believe, briefly comprise all the problems of a motor-vehicle transportation service.

Trucks, garage accommodations and maintenance facilities are included under equipment. We specialize in a service that might be called wholesale transportation and, therefore, can limit our problems, so far as trucks are concerned, to heavy-duty units, thereby enabling us to take advantage of all the economies possible through standardization. In this respect, however, we do not believe in putting all our eggs in one basket, for obsolescence works too fast and in too many ways. Some types of unit undoubtedly are more adaptable to certain classes of work than others, yet we find it more economical to sacrifice these advantages for standardization. When conditions do force us to adopt a new unit, we again have to sacrifice individual advantages for the majority requirements. Any special features that may be considered necessary to increase production on any particular job are therefore incorporated in our body designs. But we strive for as great uniformity in the features as possible.

To afford better visualization of the body problem, consider the products we handle daily: Biscuits, in cans and cartons; waste paper, in bales; box-board, loose; paper products, in cartons; molasses, in barrels and cases; tobacco, in hogsheads, bales and cartons; dates, in cases; citron, in casks; nuts, in bags; metals, in pig form; die-castings, in cases; asbestos, in bags; dressed pork, china, glassware, statuary, toys; and railroad freight in its various forms. When it is realized that individual-job demands vary from 10 to 50 per cent daily and from 10 to 100 per cent throughout the various seasons of the year it is seen that bodies are somewhat of a problem when our service includes valuable cargoes and the liability for damage due to improper protection or handling.

Fig. 1 shows our standard form of van, used chiefly in handling meat and bakery products, and any other material that is quickly damaged by the elements. Fig. 2 is our standard form of platform-stake job. In the spacing of the stakes, these bodies are usually laid out so that we can get on the body the maximum number of standard-size 53-gal. barrels. By doing this, we are always sure of the maximum load when any barrel products are to be handled, and, in handling the other types of load for which this particular body can be used, the spacing of the stakes does not make so much difference.

Fig. 3 shows one of our standard rack-jobs with a slightly sloping body in the rear. On rack trucks, we are standardizing on a panel height of about 30 in. and use either a three or a four-piece tarpaulin. After much experience in using various kinds of tarpaulin and getting our men to use them as they should be used, we found that, for fall, winter and early spring weather, if we place one piece of the tarpaulin permanently on one side and extending from the base panel to the top across the front and around to the other side, and give the driver a smaller tarpaulin to handle on top, he is more likely to cover his load quickly and not to take so many chances as he would if we tried to make him use a single heavy tarpaulin. We tried light-canvas tarpaulins but found that the light canvas failed too quickly; heavy-canvas tarpaulins dipped in paraffin were found to be too stiff in cold weather, and are very difficult for the driver to handle. On the jobs now coming through, we are also placing a door on each side. We have found that the traffic regulations change so fast that a driver making delivery in one particular street one week may go in all right but, the next week, he may find himself either a block away or reversed on the street, when working with a truck having a door on one side only. Also, as against some future city-ordinance stopping trucks from backing directly into the curb or backing in at an angle, we consider the incorporation of side-doors a very essential feature in all body construction.

The body shown in Fig. 4 is built along similar lines to those of our standard truck-body. It has a 30-in. panel, a three-piece tarpaulin and a 4-ft. side-door. This is the type of semi-trailer body used in the Long Island Railroad freight-handling work. Fig. 5 shows an armored cab. It is made of bullet-proof steel and has one window across the front and a small window on each side. We now have in service 12 trucks equipped with these armored cabs, for handling valuable products.

Garage Conditions

Maintenance, operating, material and labor costs are affected considerably by garage conditions, and the effect begins at the curb before entering the garage. A ramp having an easy turning-radius must be provided, because great damage can result from bumping a 4-in. curb. If the space on the outside edge of the ramp is not sufficient to allow the truck to turn easily, the driver will not always come around, back up and take another start forward to get into the garage without bumping the curb. Usually he takes the easiest way, unless someone watches him. Both the width and the height of the garage doorway should be given very serious consideration, particularly for long-wheelbase equipment that has wide bodies; the tendency now is to install an 8-ft. body, this being as wide as the law will allow. We find that, if the doorway is narrow, a driver is likely to jamb or rub his truck against the side of the door; this is injurious not only to the truck but also to the frame of the building. We consider 14 ft. the minimum width for a door of this kind. The height is also important because, for light bulky cargoes, the load frequently is extended above the rack. If the doorway is low, the driver may take a chance sometimes when coming in and thus damage the cargo; or a low doorway may entail the expense of unloading part of the cargo, putting it on another truck and thus splitting the shipment.

Fig. 6 shows the interior of one of our garages. Gasoline filling facilities are in front, convenient to the doorway and, in the front corner, the oil tanks are located, entirely enclosed, as shown in Fig. 7. In each garage, one man is held entirely responsible for the gasoline and the oil.

Fig. 6 gives some idea of the garage proportions that we favor. Each garage has plenty of skylights, providing ample light and being conducive to cleanliness. Note that the garage is free from posts of any kind. These garages are 95 ft. wide and 100 ft. long. This width provides greater ease in maneuvering the trucks; even with a long-wheelbase equipment, it is possible for the driver to pull out of position and go directly out of the door without backing up and starting again. Likewise, in coming into position at night, it is possible for him to pull in directly from the door, come to either side of the turn and back directly into position. By having the bumper, or curb, shown in Fig. 8, built along each side in these garages, damage to truck bodies, to garage walls, to steam lines and to water pipes is prevented, and

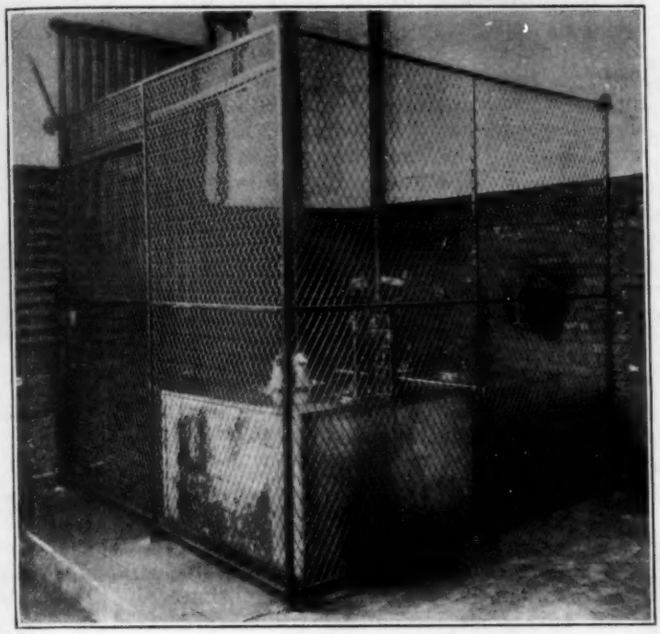


FIG. 7—OIL-STORAGE
Located Conveniently in the Front of the Garage, the Oil-Tanks Are Entirely Enclosed

also a pathway is provided for the watchman, who patrols the garage hourly and checks-in at a station in the front corner adjacent to the oil-tank. In all these garages we also have three pilot-lights right through the center, controlled by a company-owned switch, the key of which is in possession of the watchman. He turns on these lights during his first round and, without cutting through a pipe conduit, it is impossible for any one to turn the lights out. Flood-light switches are provided also; if the watchman hears any unusual noise, he can flood any portion of the garage with light. Each garage is controlled by one man; his duties are to guide trucks in and out, supply the trucks with gasoline and oil and clean the garage. The water connection is located to afford the minimum length of hose for washing purposes and the electrical connections so as to permit the use of short lamp-cords.

MAINTENANCE FACILITIES

The degree of maintenance carried on by any organization seems to be governed by varied opinions. Some see little or no value in inspection; troubles are not anticipated and equipment is operated until it fails. Even then, equipment frequently is bolstered along from day to day until serious breakages occur that make complete overhauls an absolute necessity. Operators who use such methods seem to place little or no value on service; they care little how the customers will view their road delays and consequent delays in deliveries or shipments. To them, the cost of idle time means nothing, and loss in production means less. Frequently, responsibility for lubrication and minor repairs devolves upon the drivers, and their work is checked by casual observation only. In surprisingly many instances such conditions cannot be blamed upon the men directly responsible for or in direct charge of the equipment but rather upon some official of the organization who attempts to judge motor-truck operations by the operations of his passenger cars, about which he probably knows little or nothing. These common neglects come to our notice very frequently when figuring on supplying service to large organizations; consequently, the results of many investigations and equipment appraisals have thoroughly convinced us of the necessity for a thorough maintenance plan if we expect to protect our investment and give assured service.

STANDARDIZED METHODS

We believe that standardization is the true basis for economical maintenance. Through the standardization of the motor-truck chassis, we have been able to conduct our entire maintenance system on the spare-unit replacement-plan, thus eliminating the loss of time usually experienced when major repairs are in progress. This elimination in turn reduces the percentage of idle equipment that is undergoing repairs. Also, it permits keeping repair parts and shop stock at the minimum. Having a standardized mechanical unit, one can readily understand the saving of money that would be tied-up in repair parts and shop stock required to maintain a fleet of more than 100 trucks of many varieties. Further, more economical use of trained personnel is attained. With one or two types of chassis only to maintain, it is possible to secure mechanics who are specialists in handling the several interchangeable units that make up the chassis and, with the assistance of lower-priced labor, under the supervision of the specialists mentioned, the maintenance of a large number of trucks can be accomplished economically. But, if the fleet were not standardized, it would require approximately the same number of men, all paid the specialist wage, to carry on the same amount of maintenance.

INSPECTION SYSTEM

Regarding the personnel that operates our inspection system, we believe it to be our best assurance against road delays, particularly against those that might result from mechanical failures and lack of lubrication and proper adjustment of parts that are subject to wear. To control these features or eliminate them, we require that our inspectors be men who have had good practical experience in repairing and servicing of the type of equip-

FIG. 8—GARAGE CURB
Prevents Damage to Truck Bodies, Rear-End Cargo, Garage Walls, Steam and Water Pipes and Provides a Passageway for the Watchman, Who Makes Hourly Rounds

ment we use, and that they be men who are extremely thorough and conscientious in their work.

The general plan of inspection is, first, the segregation of equipment into fleets of vehicles that correspond as nearly as possible in every detail, including bodies and the class of work needed; and, second, to assign a number of trucks to an inspector that is in proportion to the wear and tear experienced in the various classes of work, and to place entire responsibility for the performance of these respective units upon him. Each inspector maintains a regular schedule for inspection, calling for trucks in rotation, but, if at any time it is discovered that any truck in his fleet other than the one listed for inspection is in a condition that demands immediate attention, it is his privilege to call it in and make the substitution in the operating department by detailing a spare truck that is provided for this purpose.

Shop Control

When a truck comes into the shop for inspection, the chief inspector and the fleet inspector go over it thoroughly, making notes on inspection cards of all work to be done. This work is then carried out by the inspector and his assistant, if an assistant is necessary. Before the truck is allowed to leave the shop, all work is again checked by the chief inspector; the work card is then signed by the fleet inspector, approved by the chief inspector and filed under the vehicle number. If the nature of the repair work is such that a road-test is necessary to determine whether or not the work is satisfactory, the chief inspector accompanies the fleet inspector on this test, checking up all features before recording final approval on the test card. If, however, it is discovered during the inspection that repairs which might be classed as "major-overhaul" are necessary, the truck is diverted into the shop and turned over to the shop foreman to carry out the work.

When a vehicle must be serviced on the road, the driver of the vehicle is instructed to telephone the operating superintendent immediately and to state his location, the nature of his cargo, his destination and the like. If necessary, the superintendent arranges to dispatch a reserve vehicle to the point, as in cases demanding immediate transfer of the cargo. The driver of the vehicle is then connected with the chief clerk of the mechanical department, who makes out a road-job card in duplicate, and notes the time the message was received and the name of the mechanic assigned to the job. This card is handed to the chief inspector, who takes immediate steps to render the road service. Upon the mechanic's arrival at the vehicle, he notes on the card his time of arrival, the kind of work necessary to service the vehicle and the time at which he completes the work. The card is returned to the shop for filing. The duplicate road-card is sent to the vice-president in charge of operation for his information.

Fig. 9 illustrates our repair shop. The maximum amount of overhead light is admitted through a central monitor in the roof and several skylights are located on each side. In this manner we have tried to make every square foot of the shop available for any class of work without resorting to artificial light throughout the greater portion of the year. A wood-block floor covers the space used most by the workmen, for their comfort. A traveling crane runs the entire length of the garage, and a small jib-crane is mounted on one side. We have tried to install all the features that will enable us to accomplish heavy work with the minimum amount of manpower. A "sortery" is adjacent to our machine shop and yet is conveniently located for men who work in any other portion of the shop. On one side, we can line up for inspection or major repairs six to eight trucks, allowing a free space about 30 ft. wide and 100 ft. long for emergency use such as changing tires or for doing any other work in which a heavy lift or the use of jacks might be required. In one corner is a small paint shop; next to it, a blacksmith shop. Also, facilities are provided for tire and engine testing and for engine repair.

With this shop arrangement, an engine can be lifted out of a chassis at any point along the line, carried up the shop, dipped in the washing tank, removed and put on a movable engine stand, shown in Fig. 10; and moved directly across the shop into the section shown in Fig. 11, where it is completely overhauled. Afterward, it is moved back across the shop on the engine stand, lifted to the test stand, connected with an electric motor and run-in until it has the maximum amount of compression with the minimum amount of friction.

Repair Orders and Routine

Shop work and its final cost is controlled principally on a job-number basis and by comparatively few forms. Repair orders originate from four sources. First, a report covers all mechanical troubles reported by the drivers when they come in at night, and this is checked by the night inspector. If there are recorded in this report any troubles which he found impossible to remedy at night and his inspection indicates that the truck should be overhauled, this is noted on the report, which is turned in early the next morning. Second, if the inspector finds that the trouble on the road involved a major repair, he notes this on a road-job card, which he turns in to the shop office. Third, an accident report also shows a cause for major overhaul. The fourth source of repair orders is the inspector's regular inspection-form.

Only major overhauls, overhauls of spare units and special jobs are covered by job numbers. When numbers are assigned, copies of the order are distributed to the accounting department, the stockroom, the shop superintendent, the shop clerk and all individuals and departments having to do with material and labor charges against the job. One copy is attached to the vehicle.

Major overhauls may be called for through any one of these four sources, and each one of the reports may indicate a major overhaul. The reports are sent to the shop clerk, who makes up a repair order on which he lists the amount of work considered necessary.

We firmly believe that our repair shop, its personnel and our maintenance plan constitute the backbone of our service and that this is the best form of insurance we can buy for the protection and preservation of our equipment.

Drivers

It has been through the loyalty, cooperation and general good conduct of the drivers of our vehicles that we have been able to meet and, frequently, to overcome, competition. We supply uniforms to them and provide weekly laundry service.

Each prospective employe must file a detailed application. He is given a driving test by our chief inspector or an assistant and is questioned regarding his general knowledge of the equipment he will be expected to handle. If he is successful in passing this test and his previous experience indicates his ability to handle our work, his references are checked. If these are favorable,

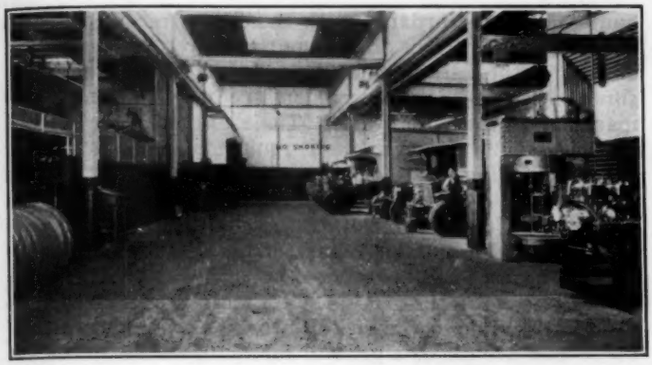


FIG. 9—GENERAL VIEW OF THE REPAIR SHOP
A Central Monitor in the Roof and Several Skylights on Each Side Admit the Maximum Amount of Daylight and Minimize the Need for Artificial Light. Other Distinctive Features Include a Traveling Crane That Can Operate Throughout the Entire Shop Length; a Free Working Space 30 x 100 Ft. in Area; Line-Up Space for Six or Eight Trucks; Machine, Blacksmith and Paint Shops; Facilities for Tire and Engine Testing and Engine Repair; an Enclosed Stockroom and Wood-Block Flooring on the Portion Most Used by Workmen

his name is placed on our list and he is notified when a position becomes available. After becoming a member of our organization, each driver is judged by (*a*) the correctness of his reports, which control certain portions of our cost distribution, performance control and billing data; (*b*) his ability to handle work properly; (*c*) freedom from complaints from foremen and customers; (*d*) the frequency and character of accidents; and (*e*) his general care of equipment. We try to attract the better men by rewarding good service with steady employment under pleasant working conditions. For the convenience and the comfort of the men, we supply lockers and towels, as well as a working blouse and a cap; these enable the men to refresh themselves at the end of a day's work. Lunching facilities are provided also. For the early-morning drivers, we provide coffee and rolls at a nominal price; also sandwiches, pies, cakes, fruit, coffee and milk for shop men at noon and for all others who desire this form of lunch.

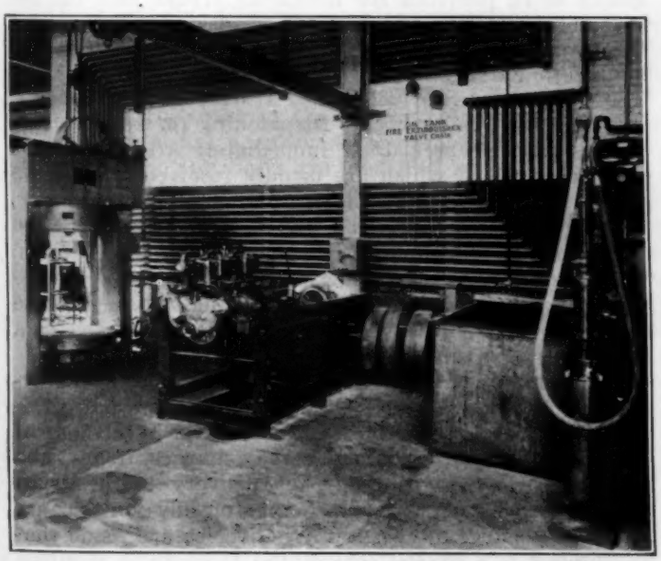


FIG. 10—REPAIR-SHOP EQUIPMENT
The Jib Crane Used Is Shown in the Central and Upper Portion; at the Left, a Tire Press and, at the Right, the Dipping Tank for Cleaning Parts. An Engine Is Shown on the Running-In Stand, Connected to the Electric Motor That Drives It until It Develops the Maximum Compression with the Minimum Friction, This Being Required before the Engine Repairing Is Considered Acceptable

CONTROL

We consider control to be our most important operating problem. When consideration is given to the facts that we give a man a $6,000 piece of equipment in the morning and practically kiss it goodby while hoping that he will return it in the evening; that, daily, we handle more than 2000 receipts that represent cargoes of more than $2,000,000 value, for which we assume full responsibility; that the trucks travel in a community where the public liability risk is greater than that in any other city in the United States; that every idle hour means a money loss; and that the loss of a trip wipes out the profit of a day's work, I believe it will be conceded that control is absolutely necessary in a motor-transportation service.

In this business, as in all other forms of business, the true basis for an intelligent control is an adequate cost-system; not a system so overburdened with details as to make its use a complicated mathematical problem and the cost of compiling far exceed the value received, but one

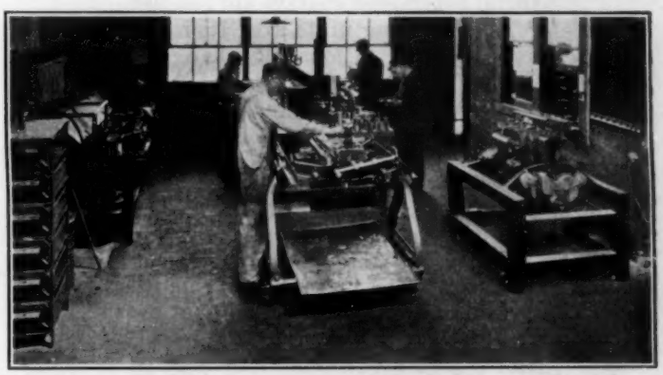


FIG. 11—ENGINE-REPAIR SECTION
Engines Set on Movable Stands Are Brought Across the Shop to This Section for Repair

reduced to as few workable units as possible and, most important of all, completely tied up with the general accounting system. Our system naturally was designed for our own use and to facilitate study and control of our own operations; also, to use the same units in studying and estimating the cost of any proposed operation. In its design and in the selection of flexible units, we therefore had to consider the possibility of making our system embody statistical information essential for other purposes, such as the controlling factors of a truck's daily work, irrespective of the class or the number of jobs, and also the data that prospective customers would be most likely to keep, having in mind that, with a common basis for comparison, the application of our costs and experience should enable us to make an intelligent study of any sort of operation.

Drivers' wages, being on a time basis, were being computed directly by prospective customers from the time stamped on the drivers' reports; loading charges, ferriage and the like were being tied up directly with trucks and jobs. Prospective customers can tell one their scale of wages, the amount or percentage of overtime and the ferriage, and the nature of the work indicates whether or not loading charges are necessary.

Truck mileage was being compiled for gasoline and oil, and tire records were being compiled from odometer readings recorded on drivers' reports. Prospective customers either keep similar records or can tell one their average daily mileage.

Days worked, for trucks, was being compiled on a

customer basis for billing purposes, and the data were also being used for insurance purposes. Prospective customers can either tell one their average daily requirements, or these can be determined from tonnage figures.

Cost System

Therefore, we segregated our costs into three general classes, as follows:

(1) *Direct Operating Expenses.*—Including drivers' wages, loading charges, ferriage, miscellaneous expenses, special supervision and all expenses that can be charged directly to a job

(2) *Indirect Operating Expenses.*—Including operating-material expense and maintenance expense. All expenses that we considered accrue on a mileage basis, rather than on any other basis

(3) *Overhead Expenses.*—Including all expenses not comprised in classes (1) and (2). These we considered accrue on a day basis, rather than on any other basis. Included also are fixed, such as administrative, charges; and storage, such as general supervision charges and the like

Therefore, our working units are: Item (1), of which drivers' wages apply to all jobs, all other expenses being incidental to the individual jobs; item (2), reduced to a cost per mile basis, which applies to all jobs; and item (3), reduced to a cost per truck per day basis, which applies to all jobs. With these few units, it is possible, we believe, to make a very comprehensive study of any sort of operation.

To cover the tie-up of these units with our monthly statement, we show at the top the total revenue from our operation, total operating expense, total indirect expense and total overhead on trucks actually at work. This enables us to tell very closely the total cost of trucks worked. We are then able to determine a profit from our operations. Applying this same overhead per truck per day to idle trucks, brings out very forcefully the cost of idle time in any one month. Below, we then indicate the profit from the operation.

Having determined the general classification best suited to our needs, our monthly statements were set up in parallel and our chart of accounts was outlined accordingly. The indirect-operating-expense and the overhead-expense units used for cost purposes for 1924 are the averages obtained for the year 1923, the reasons being as follows: Seasonable expenses and unequal-working-day months cause variations in monthly averages; consequently, to use current-month averages for current-month costs, we would lose the value of a comparison on a common basis, and cost summaries would be delayed at least 10 days while awaiting the results of statements. Further, when estimating costs of new work, the average basis is the only safe basis; if any other basis were used, it would be impossible to determine wherein the estimates deviated from the actual performance costs in the event that the work was secured.

Having this system, our next problem was to build up an organization to execute all orders properly and carry out the details that were necessary to establish the control we desired. In this process, we found it very difficult to convert the old-time truckmen who did not believe in costs and, for so many years, used the scrap-of-paper method of doing business; consequently, many of them have fallen by the wayside, being replaced by more experienced traffic-men.

Operating Organization

Our superintendent has charge of all outside work. The duties of the dispatcher are to assign men and equipment in accordance with the orders received and to coordinate operations throughout the day. Also, he is in charge of the garage office and of the garage men. The foremen on special supervision are men assigned permanently to individual jobs. Their duties are to lay out work, order trucks for their requirements and specify the dispatching time and when and to whom the men shall report. They keep shipping records and are held responsible for all complaints that may arise relative to their jobs. These men report direct to the superintendent. The foremen on general supervision are men who cover contract jobs that do not require constant supervision; also, they cover pick-up work and all emergencies. These men are under a general foreman, whose duties are to assist in coordinating all work by keeping in communication with the dispatcher at regular intervals throughout the day.

Night supervision consists of general charge of the plant at night. The duties are to check all orders covering loaded trucks with the dispatch sheet, to check and prepare for distribution all receipts turned in with drivers' reports at the end of a day's work, and to check drivers' reports with the previous day's dispatch sheets. Charge of the night-washers, mechanics, oil men, watchmen and janitors is included.

General Control

General control starts with the origin of orders that come from two sources: (*a*) from regular customers, usually through our foremen who are stationed on the job; covering trucks sent to the garage loaded, as indicated by a notation on the driver's report, a record being made on a form that is kept in a binder; and (*b*) from the sales department on a Confirmation of Work order that covers pick-up and special jobs, requiring special instructions as to performance and that a copy of this order, with rate indicated, be sent to the billing department.

The notes on the truck-assignment sheet include a definite assignment of a man to the truck, and a definite assignment of the truck to a job, in many instances; spaces being provided for indicating trucks held for repair and inspection, the destination of loaded trucks and the time of departure of all trucks. This sheet is designed to make dispatching as automatic as possible. The dispatching, for all loaded trucks, can be done as they arrive at the garage. Dispatching for regular customers can be checked off immediately after receiving the orders, all of which are usually received about 5:00 p. m. Owing to the regularity of our work, the major portion of dispatching can be completed before 5:30 p. m. and all dispatching completed before 6:30 p. m. The sheet is made up in long hand. As trucks are transferred from one job to another during the day, these transfers, together with the time made, are noted in a "second-assignment" column.

Foremen on general supervision are assigned in accordance with the orders received. In all work originating at piers or warehouses, they travel in advance of the truck. They present papers, pay charges, if any, and thus have the freight ready for delivery to the truck when it arrives. When delays occur on any job that are subject to charge, or when any deliveries are made that are subject to a special charge, the foreman is required to make a detailed report of the conditions. He sends one copy to the customer and one to our accounting or billing department.

After the drivers' wages have been computed in the garage office and entered on the drivers' reports, and

after these reports are sent to our main office, one man who is familiar with all contracts, billing requirements and the like checks all reports and notes all features requiring the superintendent's attention, classified according to jobs, thus enabling the superintendent to investigate immediately; his investigation is principally regarding delays.

Job Cost and Performance Control

After schooling our organization as to the importance of the accuracy of certain features of our drivers' reports, our job-cost and performance-control system was put into effect. In every shipping operation, our customers check our work; consequently, because of our billing by receipts, bills of lading or loading-sheet numbers, depending upon the quantity of material covered by the individual receipts or bills of lading, and for our information in placing responsibilities for errors, it is necessary to tie-up these individual movements with our trucks, using a truck number that, in turn, identifies the driver. The accumulation of these data for an entire billing-period not only presented a liability for many errors and omissions but also threw an unusual burden on the customer when checking bills for service. The individual-job sheet was, therefore, designed primarily to permit a daily assemblage of all material that passed over the customer's platform and a consequent daily check of all billing data.

Experience has proved that it is not only possible to group these units of compensation on a rate-classification basis, but also in such a manner as to give the customer his departmental cost-distribution. This complete distribution serves a double purpose; it not only reduces accounting costs for the customer, but also gives us a more intimate knowledge of his problems and enables us to discuss them with him intelligently. It is possible for us to do this only because we are able to set up our costs in parallel with the work performed; and, through our drivers' reports, we are able to isolate any divisional costs when necessary. One copy of this job-cost and performance-control sheet makes provision for a cost assembly that is accomplished as follows:

All shipments, deliveries or pick-ups are covered by a number. The foreman or clerk notes the number of the truck handling the shipment, the receipt number, the truck number, the units covered by the receipt and noted on the control sheet in the proper column; the driver, in turn, identifies delivery on his report by the receipt number. Control sheets are identified by number; daily, one copy is sent to the customer and two copies to the billing department; one of the latter containing the shipping record accompanies our bill; the other copy, containing our cost data, remains in our possession.

Drivers' sheets that are turned into the garage office each night have attached receipts that cover the last delivery made; these are checked against the report by the night-man. The drivers' pay is then computed on the following morning. At 1:00 p. m., the drivers' reports are brought to our billing department. There they are segregated according to jobs and checked against the control sheets as to deliveries. All information necessary for our cost-data records is placed in columns provided; such as total mileage in the "mileage" column, the proportion of the truck-day charged to the job in its proper column and drivers' wages in that column. All other expense items are covered by daily petty-cash statements and, in turn, are noted on these cost sheets.

All billing data are summarized and extended on a daily basis. Mileage, truck-days and drivers' wages are summarized on a daily basis; but mileage-cost units and truck-day cost-units are applied only on the monthly summaries. The summaries of these daily sheets, such as Total Truck-Days, Total Mileage, Total Drivers' Wages and Total Units Hauled, are inserted on the superintendent's report. These data are summarized on a weekly basis, and weekly summaries are averaged on a truck-day basis. Therefore, the superintendent has a complete check on each foreman's performance, the average units per truck per day being his chief concern.

If, for any reason, a fluctuation in performance occurs, an increased or decreased average mileage may be some indication of the cause; but, when drivers' wages show a marked increase per truck per day without any corresponding increase in performance, it is an indication that the job needs an immediate investigation.

Having these reports on a weekly basis, it is possible for us to give to our superintendent these controlling data a few days after the end of the week and, should any investigation be necessary, the foreman on the job, by use of the notes on his control sheet, usually is able to indicate the particular features in his work that might influence his production. If, from time to time, a repetition of features on the job which materially reduce production occurs, we are able to make an intelligent presentation of our case to our customer if the conditions are platform conditions and, in most instances, are able to have them rectified. It can be seen readily that, with this weekly control, the profit and the loss fluctuations that might occur on any particular job would mean considerable expense on our part if they were such as to demand some investigation; and the incidents affecting the matter would not be as fresh in the mind of the foreman as they are when called to his attention on a weekly basis.

On our drivers' reports, the word "delays" stands out more prominently than any other particular portion of the report, indicating our efforts to eliminate or to rectify them as quickly as possible. Space is provided in which the driver is required to make an explanation of all details. On the bottom of the report further detailed instructions are given the driver as to the purpose of the report, how to report accidents and the like.

THE DISCUSSION

Chairman A. J. Scaife[3]:—It has been said that the three essentials of a motor truck are what it costs, how much it will carry and how long it will last. The first has to do entirely with the builder of the vehicle and the second concerns the builder and the operator; but I believe the third feature, how long it will last, has to do largely with the operator. This makes it necessary that there be an operating organization as thoroughly organized and having a personnel as intelligent as that of the builder.

J. A. Hoffman:—Supplementing my paper, I desire to give due credit to R. S. Hurd, of the Pennsylvania Railroad System, for making it possible to install this way-freight truck service, and to J. C. Evans, assistant chief engineer of the Long Island Railroad, for his active cooperation in developing a workable plan of operation. I will ask Mr. Evans to explain some of the detail of the Long Island Railroad service, as he can state not only the truck-operating but also the railroad-operating sides.

J. C. Evans[4]:—The Long Island Railroad's situation regarding less-than-carload freight is rather compli-

[3] M.S.A.E.—Chief factory service engineer, White Motor Co., Cleveland.

cated. We have four western terminals; the one on Manhattan Island is for coastwise delivery and receipt and also for freight originating in department stores; the one at Long Island City handles the interchange with all the railroads except the New York, New Haven & Hartford Railroad; the third at Bushwick, in Brooklyn, accepts the interchange from the New York, New Haven & Hartford Railroad; and the fourth is at Flatbush Avenue, Brooklyn. The last serves the industrial development in Brooklyn, as the Bushwick terminal serves the adjacent territory and the Long Island City terminal serves the Long Island City territory.

Prior to motor-truck installation, each of these terminals loaded cars to various eastern branches of the Long Island Railroad. Obviously, some of these cars were not always heavily loaded. The motor-truck installation combines the three terminals located on Long Island; that is, at Long Island City, at Bushwick and at Flatbush Avenue. The freight that is destined for the branch from Long Island City to Whitestone Landing, about 10 miles long, and the branch running from Long Island City to Port Washington, about 20 miles long, is peddled by motor trucks.

The transfer of the freight received at Flatbush Avenue for Port Washington is accomplished by loading it on a semi-trailer and taking it to Long Island City for concentration. Likewise, the freight received at Bushwick for Port Washington is taken to Long Island City for concentration. At Long Island City, a zone-car is loaded; it is destined to the zone station, Bayside. The morning freight train, leaving at 2:00 a. m., takes this one zone-car, instead of three or four, to Bayside. There it is met by motor trucks and the freight is hauled eastwardly to its destination. Two trucks operate a peddle-freight service on the Whitestone and Port Washington branches. Trailers and tractors operate in the terminal district in an inter-terminal exchange. That constitutes the operation of the trucks and trailers in this territory. It covers all that has been done to date.

QUESTION:—Has this haulage company ever used any device to register idle time and moving time automatically? Is such a device feasible or desirable?

W. F. BANKS:—We have tried several such devices. Some of them were simple and registered idle and moving time; others were somewhat complicated and registered idle time, moving time with the miles traveled in parallel and also the speed at any time. The simple variety with limited control was found to be the most reliable. The more complicated variety required either transmission or ordinary odometer-drive, neither of which is tamper-proof; consequently the information derived was neither consistent nor reliable. The greatest trouble is that most men regard these devices with some degree of suspicion; hence, after turning a few corners, the machines are out of order.

SIDNEY G. HARRIS[5]:—In the event of a breakdown, do you allow your drivers to spend any time in attempting a repair? For instance, can a driver spend from 15 to 20 min. in attempting a repair, or must he call up your service-station immediately and have a road mechanic come out? Also, do you use bullet-proof glass for the armored-cab windows?

MR. BANKS:—The driver must notify us immediately whenever a road difficulty occurs. If, while telephoning the mechanical department, he is able to explain his difficulty intelligently, and the chief inspector knows the man has the ability to make the repair, he tells him to go ahead on his own responsibility. Many drivers are very good mechanics. Those men are sometimes allowed to make minor repairs. Other drivers are not mechanics in any sense of the word and for that reason we have established a general policy of requiring every driver to telephone in case of any mechanical trouble, allowing our shop superintendent to use his discretion as to whether the man should be allowed to attempt the repair.

I believe an armored cab would be of little value as an armored cab unless it were equipped with bullet-proof glass.

[4] Assistant chief-engineer, Long Island Railroad Co., Jamaica, N. Y.

[5] Jun. S.A.E.—Sales engineer, Metropolitan Body Co., Long Island City, N. Y.

STREET AND HIGHWAY SAFETY

(*Concluded from p.* 58)

the National Association of Railroad and Utility Commissioners, the Eastern Conference of Motor-Vehicle Administrators, the Bureau of Standards, the American Engineering Standards Committee, the Highway Education Board, the National Safety Council and other National associations. An outstanding contribution to the attainment of uniformity was rendered during the war by the Highway Transport Committee of the Council of National Defense, and directly following the war by a joint committee of representatives from the American Association of State Highway Officials, the National Automobile Chamber of Commerce, the American Automobile Association and the Highway Industries Association. These groups, after many meetings, formulated a proposed uniform vehicle-law, many principles of which have since been incorporated in various State laws. The Motor-Vehicle Conference Committee has also been rendering valuable service in working for the adoption of uniform principles of regulating the size, weight and speed of vehicles. Similar constructive work in the development of uniformity in other branches of traffic safety should be immediately undertaken and pushed as rapidly as possible through the operation of voluntary committees.

Durability of Plated Surfaces

By W. M. PHILLIPS[1]

PRODUCTION MEETING PAPER

THE discussion following the presentation of this paper at the Plating Session of the Production Meeting was constituted largely of written questions and oral replies by the author. In accordance with the usual practice, the stenographic report of these remarks has been submitted to the various speakers for their approval and to the author for any additional comment that he cared to make. The corrected discussion, as received, is printed below. An abstract of the paper precedes the discussion so that those of the members who did not read the paper when it was printed in the November issue of THE JOURNAL can gather some knowledge of the subjects covered by reading the abstract if they do not wish to take the time to read the complete text.

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

SUITABLE physical characteristics of the plate and a thoroughly clean metal surface upon which to deposit it are essential if an adequate thickness of plating is to be attained to make it durable. It pays to provide a good metal surface to receive the plate.

Adequate cleansing of the surface to be plated cannot be overemphasized. This can be accomplished by using, in all preliminary operations, only greases that can be removed easily, by using suitable equipment and the proper type of cleaning compound, and by dipping in a pickling solution of hydrochloric acid and water.

All the abrasive-wheel operations before the actual plating is done are included in the term "polishing" and, since it requires skilled workmen, plating can be done more economically if this item of cost can be lessened. When the cost is fixed, it often is best to spend less on the polishing and more on the plating.

Steel plated with nickel is considered next, tests having shown that the average thickness of nickel-plating on a certain car was only 0.0001 to 0.0002 in., or less than one-tenth the thickness of tissue paper. Since the other protective coatings, the paint and the enamel, vary in thickness from 0.002 to 0.004 in., arguments are presented in favor of making the nickel-plating thicker.

Some details of plating are discussed and illustrations of plating and testing equipment are presented. The cost of the usual grade of nickel-plate is compared with that of the so-called heavy plate, to the advantage of the latter, and the necessity for using laboratory methods throughout the process is emphasized. In conclusion, five of the main ideas expressed in the paper are specified briefly.

THE DISCUSSION

QUESTION:—Are the salt-spray tests continued for 24 hr.? How often are the test-pieces examined?

W. M. PHILLIPS:—The salt-spray tests are not always continued for 24 hr. As you probably know, the air for operating the salt-spray test often comes from the shop. We can only note the time during which we actually run the test; then the object is washed and cleaned and put in again the next day. The total number of hours taken is the actual hours that the object is in the salt spray. We take specimens every day and chart the results.

QUESTION:—How do you keep the joints tight on the doors of the salt-spray apparatus?

MR. PHILLIPS:—We do not.

FLOYD TAYLOR:—Mr. Phillips stated that the elimination of two of the wheel processes would give him 18 cents to work on. How far would that 18 cents go, if it were applied to doubling the thickness of the plate? If you analyze the cost of plating you will find that a large part of the total cost, without going into a definition of what is meant by cost, is in labor, in the handling of the article. Is that cost increased appreciably by doubling the thickness of the nickel?

MR. PHILLIPS:—Let us assume that a radiator shell contains about 7 sq. ft. If you have a 0.0002-in. plate and want 0.0004 in., I should recommend at least 0.0006 in. You will probably not increase the cost more than 10 cents, we will say, depending on the conditions in the shop. It costs more, of course, to put on that amount of metal in some shops than it would cost in others. Among our own divisions it costs more to do it in one place than in another, depending on the nature of the apparatus and the like. The polishing cost would probably be 60 cents, as a rough figure.

QUESTION:—Is the filtering of the copper and the nickel solutions done while the tanks are in operation?

MR. PHILLIPS:—Yes.

QUESTION:—What progress is being made with automatic polishing-machines?

MR. PHILLIPS:—We find automatic polishing-machines for some objects to be developing very satisfactorily. I might say that you must have a large number of pieces to make such equipment feasible. In the City of Detroit are several automatic machines, where single pieces are produced in large quantities. When the quantities are small, I do not think such machines will ever be entirely practicable.

QUESTION:—How often are the solutions filtered?

MR. PHILLIPS:—The solutions are filtered whenever they get dirty and that will depend to some extent on the amount of operation, the time of the year and the like. In the summer, the windows are open and the solutions are likely to get dirtier than in the winter when the windows are closed; consequently, we must filter more often in summer.

QUESTION:—Are the solutions controlled as to acidity?

MR. PHILLIPS:—The acidity is controlled. I think the control of the acidity in the nickel bath is the most important item of chemical control. By that I mean the determination of the *pH* value.

R. L. SHEPARD:—Do you find that when the solutions are controlled as to acidity slime accumulates, particularly nickel hydrate and ferric hydrate?

MR. PHILLIPS:—Not much. The amount of slime has been reduced materially by controlling the acidity. But we still have some. A large quantity is found in the bowl of the centrifuge when it is taken out.

[1] General Motors Corporation, Detroit.

MR. SHEPARD:—How often is the acidity controlled? Every day, or once a week?

MR. PHILLIPS:—Even oftener than once a day.

MR. SHEPARD:—That agrees with my experience. I have solutions, in which the acidity has been controlled carefully by adjustments every day, that show no slime; and they have been in operation for a year. We are beginning to settle them and strain them merely to get rid of the accumulation of dirt and carbon that comes from the anodes, but we have no accumulation of slime over a period of a year.

MR. PHILLIPS:—If the acidity is controlled carefully you need not do much filtering, unless the plating tanks are located close to the buffing-room. In a plant in which the tanks were located next to the buffing-room, it was necessary to take out the lint and other things that got into the tanks.

CHAIRMAN F. A. CORNELL:—In other words, the necessity for filtration arises from two general causes: the by-products of the processes in the tank and external mechanical pollution.

MR. PHILLIPS:—Yes. The anodes are important, too. If the anodes are full of iron and carbon, particularly carbon, the solutions must be filtered more often.

QUESTION:—The salt-spray test is good for nickel on steel; what about nickel on brass or zinc alloys?

MR. PHILLIPS:—On brass, not so good; on zinc, it will give fair indications. On zinc, a white stain develops that is comparable with the brown stain of iron oxide. I do not believe it tells the story on brass.

QUESTION:—How could you leave out any polishing or buffing operation on brass that is nickel-plated and still get a good finish?

MR. PHILLIPS:—The only way to do that is to drug the inspector. The brass comes to you in about the shape that you will plate it, except for the polishing operation. Nickel is harder than brass, so you will not make the wheel operations any easier by piling on more nickel.

QUESTION:—Do you think that two or more deposits of nickel would be more durable, as you mentioned in connection with plating?

MR. PHILLIPS:—Yes; particularly if the two or more deposits are put on under different conditions as to current-density. A certain structure is set up in the nickel under one set of conditions and another structure under the other. A certain staggering of crystal growth would result that would give greater durability.

QUESTION:—Does not the brightness of a nickel deposit indicate a closer grain and better wearing quality?

MR. PHILLIPS:—I think that it does indicate a closer grain-structure and that it is probably more durable. We are trying to devise a machine to test out that quality. We shall get many bumps before we arrive at an answer. Our idea is some kind of friction-type machine that will produce a certain amount of wear of the object in order to see how long it will take to wear through. We shall be able to answer that question better 6 or 8 months from now.

CHAIRMAN CORNELL:—You indicated that 48 hr. of salt spray was satisfactory for zinc-plated Jaxon rims, something of a standard, but that it did not do so well on nickel. What would be a comparative salt-spray passing-point on nickel that would correspond to the 48-hr. point on zinc-plated rims?

MR. PHILLIPS:—Twenty hours, we will say, is a point that many persons try to reach. The way of judging that 20 hr. is another matter. If you remove the object at the first appearance of rust, perhaps 20 hr. is a little severe. To compare it with the 48-hr. zinc plate, we ought to scale that down somewhat, because steel, in spite of all our care, contains certain flaws and pits that will produce an appearance of rust long before the whole thing will rust. In our plants we are aiming to set two standards, one for the first appearance of rust, at approximately 10 hr., the other for a general appearance of rust, at approximately 20 hr., with the idea of making that test more severe later on.

CHAIRMAN CORNELL:—Have you tabulated, as I believe Professor Baker did last year, any approximate arbitrary rating in that regard? That seemed to impress many persons.

MR. PHILLIPS:—With due respect to Professor Baker, his table contains many steps in inspection that, beyond the first one, depends entirely on the personal factor. He has, for instance, "very slightly rusty," "slightly rusty" and "very rusty." All those terms may be interpreted differently by different persons, so that, although his move was a good one, we have omitted some of the steps. We call the first appearance of rust that which anybody can see, and then let the man use his own judgment and say "general rusting," and hit an average between the steps, which would be between 8 and 20 hr. in our case.

QUESTION:—Do you get uniform results in the salt-spray test? If not, what is the value of the salt-spray test? Would not a quicker test be better for commercial use?

MR. PHILLIPS:—We do not get uniform results in the salt-spray test. The reason is in the variable methods that we are using. We nickel-plate a piece of steel in one case and a piece of wrought iron or of cast iron in another. Even on the same pieces, if they are made of sheet metal, the sheet steel itself will vary so much that, even if the processes were absolutely uniform, we should not get uniform results.

The value of the test is in indicating general durability. The United States Government developed a salt-spray test, after having tried a great many other methods of testing plated metal, and settled on it as the only reliable test. They did not say that it told the whole story and it does not, but it does indicate durability.

QUESTION:—Would not a quicker test be better for commercial use?

MR. PHILLIPS:—Yes. I hope the man who wrote that will get one, because we should all like to have it.

A MEMBER:—It was interesting to me to see how closely the salt-spray test and the acid test corresponded at the Remington Typewriter Co. They make eight tests and determine that a piece should endure so many hours. They specify from 45 to 50 hr. for parts of the Remington typewriter.

They also make an acid test. The acid test consists of simply painting a little of equal parts of sulphuric acid, nitric acid and water on the piece of work and watching to see how long it will take for the acid to eat through. A heavy deposit that would withstand the salt-spray test will withstand the acid for 4 or 5 min.

I also tried that test at the Packard Company more than a year ago. I obtained a piece that would last for 30 sec. I have seen one of the same pieces from another solution that lasted more than 3 min.

So, I believe that a test that would be suitable for any plater to use during the progress of the work is simply to mix equal parts of these acids and water, put a drop on the piece and watch the acid eat through. If it en-

dures for 1 min., you have a good coat of nickel. We have done it in the Ternstedt Company. We did not seem to be getting a thickness that would last. I found that under the acid test it would not stand from 15 to 20 sec. We increased the coating so that it lasted for more than 1 min. 35 sec. We have found that this deposit was a good deposit.

I believe that a quick test can be made in that way. You can do that during the day, when in doubt, and then request the chemist, or whoever takes care of the salt-spray test, to verify the figures.

CHAIRMAN CORNELL:—If anyone is interested in making tests quickly, he might try out this test. It is inexpensive and can be used on a small surface with the minimum loss of material.

MR. GRAVES:—How can you tell when you have finished?

A MEMBER:—By the action of the acid. You can watch it and can tell the instant the acid strikes the base metal. Just put on a drop of acid and let it eat; when it begins to boil, blow it off and you will see the base metal underneath. The test applies equally well to brass, iron or steel. I cannot say how it would work out on the different castings in which you are interested, but I believe it would be just as practicable for them.

CHAIRMAN CORNELL:—Would not the color in the salt indicate the difference?

A MEMBER:—It is indicated by a different action.

L. K. SNELL:—Was the last test to determine the thickness of the deposit instead of searching out the defects in the whole surface of a piece?

MR. PHILLIPS:—It would necessarily be so. It would hardly be practicable to dip a whole radiator-shell into the acid, as that would involve putting the whole radiator, possibly, into the salt spray, but if you wanted to test a particular point that you suspected to be weak, you could apply the acid drops and perhaps get an indication. What is desired is a quick test by which the plater can ascertain how he is coming out at a given time, not 48 hr. later.

A MEMBER:—The Preece test is good on zinc.

MR. PHILLIPS:—The United States Bureau of Standards test, yes; but they pay for material on the basis of the salt-spray test.

A MEMBER:—Undoubtedly, the salt spray is more effective, but for a quick test the acid test is a good one.

QUESTION:—Is it possible to use phosphoric or any other acid that would form an insoluble salt in the pores of the plated surface to prevent rusting, possibly a 2-per cent solution of H_3PO_4?

MR. PHILLIPS:—That is something that I have never tried. We use phosphoric acid for various rust inhibitive coatings. They retard the formation of rust to some extent. There might be some such possibility.

QUESTION:—Is there any method of production control, either by laboratory test or otherwise, to parallel the salt spray?

CHAIRMAN CORNELL:—In some respects this question is answered by this quick test and by the Preece method.

MR. PHILLIPS:—When you have a fairly large plating operation it is a good plan to keep track of the amperage carefully. If you get so many amperes per minute on each piece of work, as Mr. Graves has mentioned, you will be sure that the thickness is correct. Thickness is a most important factor. This method is not a test but a control.

QUESTION:—Would not a burnishing operation help to smooth out the surface before the final nickeling?

MR. PHILLIPS:—Yes. I have seen that done many times on the nobler metals, gold and silver, but I do not believe that it could be done cheaply on large commercial pieces. It would help, for absolutely 100-per cent workmanship could be secured by burnishing the surface.

MR. SNELL:—How much will a double coating of nickel increase the cost of the polishing operation for the final finish? It costs a given amount to polish a certain piece with the minimum coat of nickel on the piece. If that deposit of nickel is doubled, how much will the cost be increased?

MR. PHILLIPS:—If you double the coating of nickel, it will not increase the polishing cost at all, but doubling the copper will increase the wheel expense a little, because you will have to buff harder to get the heavier copper coat smooth.

MR. SNELL:—I thought the same thing would probably apply to nickel.

MR. PHILLIPS:—Not to the same extent. If you have 0.0001 in. of nickel and put on 0.0002 in., if the solutions are controlled, you will not be able to tell the difference in the color.

MR. SNELL:—If a gray nickel coating is used, the surface is so rough that you cannot keep it clean, due to the crystals' being raised up in the surface on account of the deposit of nickel required to produce the gray nickel finish.

MR. PHILLIPS:—You are correct, if you have that condition; but it is not necessary that the nickel should be rough even in fairly heavy deposits. I have a piece of nickel that averages about 0.005 in. in thickness and it is perfectly smooth.

A MEMBER:—I believe that burnishing is feasible on a great many pieces. In Waterbury, buttons ordered by the United States Government for use in the navy and the army are never buffed; they are always burnished on a lathe. The workman burnishes them as quickly as he could buff them. You never see any buttons that have been cut through. As regards the nickel on the work, one buffer may cut off a great deal and another buffer who knows just how to handle the buffing-machine may take off very little. In burnishing, you take off just so much. I believe that the very fine abrasive would give a wonderful test of the wearing quality of the nickel deposit. The salt-spray test is very good, but it will not tell how much nickel you have. It will, of course, tell how long that amount will withstand the wear of the hand on the car.

MR. PHILLIPS:—We have a machine partly made but are still wondering just how to complete it. Many factors enter into making that test a fair one. We must determine what they are before we can actually complete the machine.

JOHN MCGEORGE:—I have seen considerable burnishing done on various objects. In fact, I used it myself in the old times, particularly on steel. The statement has been made that polishing filled up the scratches. If it does, it can only do so by burnishing. If it were simply a rubbing, it would take off the high spots but would not fill up the low spots. If the low spots are filled up, evidently burnishing is going on. Why not carry the operation still further and do the whole thing by burnishing?

MR. PHILLIPS:—The terms, polishing and buffing, are sometimes used incorrectly. Polishing generally means the using of a wheel with abrasive that actually cuts and cuts profusely, whereas buffing is more of a combination of burnishing and polishing. At the present time we are doing burnishing to a certain extent. Nickel cannot be colored without a certain amount of burnishing. We have increased the speed to 3000 r.p.m.

FLOYD TAYLOR:—In coloring nickel with lime, the action unquestionably is a double one of abrasion and of deoxidization, because the lime is slaked during the coloring operation. We talk a great deal about the amount of nickel that is put on. How much is taken off in the final coloring operation? That factor has come to the front in a large way in the question of nickel-plated plumbing supplies. Considerable discussion has arisen as to what constitutes a satisfactory nickel-coating for plumbing supplies. The Bureau of Standards has been working on that problem for some time. The question of tests, dip tests and similar ones, has been discussed thoroughly by chemists in attempting to establish specifications for the nickel-plating of plumbing supplies.

In the early days a good deal of nickel coloring was done with a rouge but this has been discarded for several reasons. The difference between coloring with rouge and coloring with lime is that rouge coloring is a burnishing operation. Lime coloring is, as I have stated, a combination of abrasion and deoxidization. Rouge particles, and rouge is a sesqui-oxide of iron, are more or less spherical, and may be imagined as small steel shot. They roll down the plate and, therefore, perform a burnishing operation.

RECONSTRUCTION OF DEVASTATED FRANCE

BY last July, according to statements by authorities in France, approximately 80 per cent of the houses damaged in France during the war had been rebuilt, 90 per cent of the damaged canals had been reconstructed, 80 per cent of the trenches used by the troops of both armies had been filled in and 88 per cent of the damaged factories had been put into operation. While to a great extent the repairing of the damage done in these regions was executed with Government aid, nevertheless much is due to the energy and industry of private individuals and owners. Reconstruction has gone forward at an increasingly rapid rate during 1924; with nothing intervening to interrupt the present progress, it may be definitely completed before the middle of the current year.

The pre-war population of the regions under consideration numbered 4,690,183, while at the close of the war on Nov. 11, 1918, this number had been reduced to 2,075,067. On Jan. 1, 1924, the population amounted to 4,253,677, or only 436,506 less than at the opening of the war. In 3239 out of 3255 communes the local administration has been fully reorganized, and the number of public schools and post offices in these districts exceeds those of pre-war years.

Shortly before the close of the war, a corporation was organized, known as the Credit National, whose purpose was to facilitate the repair of the damage caused by the war. The company was formed by a group of the most important French banks, with a capital of 100,000,000 francs, and its declared object was the payment in cash of compensation due to those who had suffered damage from the war and to arrange for the payment of interest on such advances. Up to April 30, 1924, claimants had been paid 54,000,000,000 francs. Various methods of payment were adopted, some in cash, some in kind and others in Government securities. Approximately 28,000,000,000 francs still remain due to sufferers of the war.

It is estimated that the number of buildings existing in the devastated regions prior to the war was 1,190,066. Of these, 893,792 were either completely destroyed or damaged to such an extent as to be incapable of use. Only a small number of the dwellings actually destroyed have been definitely rebuilt or completely restored. In many cases wooden dwellings of a temporary character have been constructed. It is the intention to build permanent dwellings and houses of a character similar to those in existence in pre-war days.

The work of reconstruction has made remarkable progress and, if continued at the present rate, complete rehabilitation of the districts may be expected at least before the close of the year 1925.—E. A. Welden in *Commerce Reports*.

THE STATUS OF BRITISH INDUSTRY

IT is estimated that before the war between 25 and 30 per cent of the national income of Great Britain was derived from foreign trade. To certain great industries the export trade is even more important than this percentage indicates. For example, in the pre-war period Great Britain exported about four-fifths of the cloth produced in the cotton mills and about half of the output of woolen and worsted tissues. Again, according to a recent British estimate, in the case of iron and steel, some 75 per cent of the output is exported, directly or indirectly, and in the coal trade about one-third of the production is exported and a large proportion of the remainder is consumed by industries dependent upon export trade.

The volume of exports for 1923 attained nearly 75 per cent of the pre-war figure and reexports and imports reached respectively 81 and 93 per cent. The decline in the volume of Great Britain's trade has been to an important degree the result of a world problem, and the reduction in the volume of total world trade has been relatively greater than the decline in British trade.

The marked reduction in the number of unemployed in Great Britain is strikingly shown by the percentage figures of workers covered by Trade Union returns and by Unemployment Insurance Acts, the percentage of unemployment for June, 1921, being respectively 23.1 and 17.8, while for June, 1924, the respective percentages have been reduced to 7.2 and 9.4. The London *Economist* estimates that about 1,000,000 more people are available for employment in Great Britain than before the war and that in normal times not far short of 500,000 workers would be on the register seeking employment.

Taking British industry as a whole, the volume of production and trade has made encouraging progress toward the level of 1913. When we turn to the profits of leading industries, it is found that for the most part a very fair return has been earned upon the capital invested. The recent rate of earnings, if not as high as in the prosperous year of 1913, has attained a percentage that compares favorably with the average percentage of the immediate pre-war years.—*Commerce Monthly.*

Engines for Oil versus Oil for Engines

AT the February, 1924, meeting of the Buffalo Section an interesting discussion took place regarding the frictional losses in automotive engines that are caused by the varying qualities of the lubricants used. L. H. Pomeroy cited some experiments conducted by him with a view to ascertaining the relation of the lubricant to the internal friction of the engine at various speeds. A. L. Clayden in reply stated that the function of the lubricant was apparently misunderstood by engineers and that more research on the subject would be made by the oil refiners if they were given more encouragement to do so by the engineers who are responsible for the design of the engines using the oil.

Additional discussion followed the presentation of the papers and this is printed herewith, including written contributions submitted and the remarks made at the meeting. In every case an effort has been made to have the speakers correct the report of their remarks and the authors reply to the discussion, both oral and written. Corrections and comments that have been received are included herewith. For the convenience of the members, a brief abstract of each paper precedes the discussion. Members who desire to refer to the complete texts as originally printed and the illustrations that appeared in connection therewith are referred to the March, 1924, issue of THE JOURNAL.

MECHANICAL FRICTION AS AFFECTED BY THE LUBRICANT

BY L. H. POMEROY[1]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

VERY few data seem to be available on the frictional losses in automobile engines caused by the failure of the oil to perform its function as a lubricant. The researches of the Lubrication Inquiry Committee in England indicate that the friction of a flooded bearing is proportional to the speed of the engine, the area of the bearing and the viscosity of the lubricant and is independent of the pressure and of the materials composing the surfaces that are opposed to each other in the bearing.

The principal sources of friction in an engine are the crankshaft, the camshaft and the connecting-rod bearings, which rotate; the pistons and the valves, which slide; and the auxiliaries, such as the generator, the pump and the distributor. Experiments by the author led to the conclusion that a variation in the viscosity of the lubricant can easily account for reduced mechanical efficiency and consequently for the increased consumption of gasoline, and that the friction-loss is proportional to the cubic capacity of the engine, whereas the brake mean effective pressure for the same horsepower is inversely proportional to the capacity. Tables are given showing the variation of the friction mean effective pressure at various speeds and at various temperatures of the water and the oil, the fuel consumption of the engine at part throttle and at varying oil and water temperatures and a method of calculating the reduction of the gasoline consumption, assuming a constant indicated thermal efficiency. The identity of the results, as determined from the friction curves and from actual tests, is said to suggest that the thermal efficiency is affected but little by the water-jacket temperatures and that the saving on account of the thermostats and the radiator shutters is caused almost entirely by the reduction in the viscosity of the oil. Because of thermostatic control the water temperature rises very rapidly to 120 deg. fahr. in short runs and to about 170 deg. fahr. after 15 or 20 min., but the oil temperature, even for periods of 30 min. of city driving, does not rise more than 40 deg. fahr. above atmospheric temperature, and after prolonged fast driving the rise amounts to about 90 deg. fahr. On the assumption that the temperature-difference between the oil and the atmosphere is independent of the atmospheric temperature, it is shown that to obtain a mean oil and water temperature of 170 deg. fahr., the condition of maximum efficiency, with water at 170 deg. fahr., the atmospheric temperature must be about 80 deg. fahr. if the car is driven at approximately 40 m.p.h., while for ordinary city driving the conditions of maximum efficiency are not realized unless the atmospheric temperature is about 130 deg. fahr. The suggested use of thin oil might not avail because in winter very severe conditions of load and speed are frequently encountered and a slight difference in the viscosity might be of great importance.

In making a study of methods of keeping dirt out of an automobile-engine crankcase, it was found that certain oils that worked well under normal conditions became too viscous in cold weather. This was remedied by making the troughlike conduit of wire gauze through which the oil when sufficiently hot drops into the main body of oil in the oil-pan. The property of oiliness increases in importance as the bearing surfaces more nearly touch each other, and especially when the engine is starting from rest.

THE FUNCTION OF LUBRICANTS

BY A. L. CLAYDEN[2]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

IN engine design the fact that the engine must be lubricated is apparently overlooked. Few engineers realize the difficulty of doing it properly. With proper lubrication the life of the average engine would be doubled and probably quadrupled, because under the usual conditions the engine is lubricated only a part of the time. The function of the lubricant is not to take the place of cast iron, to make an octagonal bearing round, or to force its way to the right spot against resistance. Too great stress is laid on design; when cylinders are round and piston-rings fit perfectly, the amount of dilution is negligible, unless the manifold system is below the average.

[1] M.S.A.E.—Consulting engineer, Cleveland.

[2] M.S.A.E.—Chief engineer of gas engine research, Sun Oil Co., Philadelphia.

The function of oil is to provide a film upon which the piston and piston-rings may slide, not to prevent the escape of expanding gases by blocking up the cracks in the cylinder. Too much time is devoted to the design of trick piston-rings when better results could be obtained by producing accurate cylinders. It is the rule, rather than the exception, to find 25 per cent of solid matter in crankcase drainings.

Tractor engineers have learned that the life of cylinders and pistons can be measured in hours if the breathing-in of abrasives is not prevented. Several methods of accomplishing this have been tried: (*a*) by providing an oil-screen around the pump that will admit oil but exclude foreign matter, (*b*) by using a fine-mesh screen, not fine enough to exclude fine dust but fine enough to clog and prevent the flow of cold oil and (*c*) by using a fine screen but assuming that although it would clog, enough oil would force its way through to furnish the requisite percentage for use. Most engineers seem to assume that if oil is put into the engine it will find its way to the proper place somehow. Today attention is being paid to providing ample lubrication, but not enough attention is paid to the condition of the oil. Oil refiners would make more accessible the meager amount of information on lubrication that is available if they were given proper encouragement by engineers, researches on lubrication being usually looked on as purely academic and of no practical value.

Thermostatic control was formerly more important than it is at present with modern types of manifold. It is valuable principally in heating oil in cold weather and cooling it in warm weather. In addition to being difficult to construct, oil-coolers usually have the effect of chilling the film in direct contact with the surface and interfering seriously with the cooling efficiency of the radiator. A comparatively heavy oil intended to be operated warm accumulates less fuel than a comparatively thin oil intended to be operated cool. Manufacturers' instructions usually consist of the statement that the oil should be changed after a definite mileage. The two objections to this are that the instructions generally are not followed, and that draining rarely removes more than one-half the accumulated solids from the oil-pan.

THE DISCUSSION

D. MYLAND:—The average layman who operates an automobile is rather a docile individual. He asks, we will say, for 1 qt. of oil and takes what is given him. He knows no better and never will know any better, because the builder who sold him the car never tells him anything more about the oil than to say: "Use any high-grade medium lubricant." If laymen talk to an engineer about lubricating oil, he will say he is busy conducting experimental tests. The result is that the layman does not get a chance. If the engineer tries to tell him anything, in figures, the layman will say that figures mean nothing to him. So we try to inform the general public. When we convey the information in technical terms, the public does not understand it, even when the builder quotes the specifications and states values for the flash and fire tests. What person will go around with a viscosimeter in his pocket? We are trying to sell the public lubricating oil at a reasonable price, and we believe we are doing it.

G. A. ROUND[3]:—I agree with Mr. Clayden and Mr. Pomeroy that the effect of oil viscosity on engine efficiency should be considered in recommending lubricants, but I believe that the tests Mr. Pomeroy conducted are not truly indicative of service conditions, since even average dilution changes viscosity greatly. I suggest a repetition of these tests with 5, 10 and 15 per cent of kerosene added to the oil. I believe that tests of an engine under load are more accurate than frictional runs, since the sealing effect of oil also enters and is a factor, particularly in heavy-duty slow-speed engines. The need for a temperature-control device is proved conclusively by Mr. Pomeroy; this is of great value in reducing dilution. Our test work indicates that the oils of lowest viscosity that we recommend for passenger-car work possess adequate lubricating value to meet practically all operating conditions, even when the oils are diluted considerably. I believe that Mr. Pomeroy's deductions from the tests he conducted are sound. But other factors should be considered. When selecting the correct grades of lubricating oil to meet the requirements of different types of automotive unit, we consider four factors; namely, operating temperatures, oil distribution, mechanical efficiency as affected by sealing qualities, dilution and friction losses and, finally, carbon sensitiveness. For passenger cars and trucks, we seldom recommend oils of more than 60 sec. viscosity at 210 deg. Fahr. A review of the specification charts of 1924 units of American, British and Continental manufacture shows that a large percentage of engineers favor oils of much higher viscosity, in contrast to Mr. Pomeroy's belief. Owners and garage men also favor high-viscosity oils. Only a policy of cooperation and education will overcome this.

MR. LADUE:—Mr. Pomeroy has said previously that the engineer is expected to design something for $1 that any fool can sell for $2 and wants the oil man to supply something that will enable the engineer to do this, a requirement that is beyond the capability of the oil refiner.

MR. PURDUE:—If we had a "drier" gasoline, would we need to worry about the oil so much? Does not the "dryness" of the fuel materially affect the viscosity of the oil? Is not gasoline being made more "wet," continuously?

C. H. BIERBAUM:—What thickness should the oil-film have and what should be the amount of mechanical clearance? In practice, for machinery in general, we have clearance allowances all the way from 0.0002 to 0.0060 in., depending on the kind of machine, the kind of oil and the temperature and speed conditions under which the bearing is operated. With a series of bearings on an automobile engine that are run at different speeds, the clearances should be in proportion, since one oil only is used in the engine. The proper clearances for the different bearings should be considered first. If this point is not considered, the oil may be a curse, for it is absolutely essential to keep the bearings free from metallic contact with the shafts. This is a subject on which much research work could be done. The design and operation of any one particular bearing will also determine whether that bearing should have an oil of higher or of lower viscosity.

W. R. GORDON[4]: Viscosity, as dealt with in the previous discussion, is of primary importance. It is one of the few characteristics of an oil that may help the shop men to determine its lubricating value. In the last two years, in connection with our service department, I have noticed that shop men do not know just how long an oil may safely be used in an engine; so, I made laboratory tests on an engine oil with a viscosimeter used under summer and under winter conditions. Under operating conditions in winter, I find that one might run only 180 miles and cause the oil to become useless as a lubricant because of over-priming; the car being used daily from home to business and return and never becoming really warmed-up. With the same oil in summer, one could run from

[3] M.S.A.E.—Assistant chief of the engineering division, automotive department, Vacuum Oil Co., New York City.

[4] M.S.A.E.—Truck experimental engineer, Pierce-Arrow Motor Car Co., Buffalo.

1500 to 2000 miles without seriously diluting the oil. As a result, I designed the viscosimeter shown in Fig. 1. It has two glass tubes of the same bore. The shorter tube is filled with new engine-oil except for an air-bubble ¾ in. long that is left in the tube. It is then sealed at both ends. The longer tube is sealed at one end and has a cork in the other. Used oil from the engine is put in the long tube with a rubber-bulb filler, leaving about a ¾-in. space for an air-bubble. After corking the long tube, the instrument is turned upside down quickly. If the bubble in the long tube reaches the top before the bubble in the short tube does, the oil should be discarded. If, on the other hand, the bubble in the short tube reaches the top before the bubble in the long tube does, the oil is fit for further use.

Instruments for testing viscosity, such as that shown in Fig. 1, have been in use for the last 18 months and are intended for shop foremen, to enable them to make a quick determination of the condition of the oil in an engine. Dilution and pollution are the serious reasons for discarding engine oil, and the degree of each can be determined simultaneously when the instrument is held to the light. The relative rate of rise of the bubbles in tubes A and B indicates the dilution factor, and the color of the oil when it is viewed against the light indicates the degree of pollution. This instrument and the method of testing obviate the use of a thermometer and a stop-watch. It should be borne in mind that the "master" oil in tube A is exactly suitable and that it is the oil which was removed from the crankcase that is in question. The poorer the quality of the oil is, the more rapid the rise of the bubble will be; the better the condition of the oil is, the slower the rise of the bubble becomes. The comparative speed at which the bubbles in the tubes rise is a good index of the condition of the oil and of valuable assistance to a trained shop executive in deciding upon the *advisability* of changing the oil in the engine.

MR. SMITH:—Will Mr. Clayden state what effect on the lubricating quality of an oil a 10-per cent dilution has, assuming that no foreign particles are present in the oil? I think that the dilution factor can be overemphasized considerably. I believe that very soon we shall be able to prevent dilution.

MR. WIER:—No logical solution of the problem of engines for oil versus oil for engines has been reached. The viscosity of oil changes very rapidly at lower temperatures. This difficulty could be overcome by using the exhaust gases to keep the oil at a constant temperature. We have had a number of complaints that ice formed around the strainer. If the oil were heated, this trouble would be overcome.

MR. SMITH:—I have worked on the problem presented by fatty acids; in developing lubricants, any heavy oil is compounded with fatty oils. But, as I see it, the worst thing we have to contend with is not fatty acids. The fatty property of the oil and the low gumming-factor are more important than the acid-content itself.

J. W. WHITE[5]:—The piston-rings on the pistons apparently are used as scrapers to make a good fit. On a high-priced car the crankshaft is run-in for the equivalent of 400 or 500 miles. The pistons are also run in. When pistons and cylinders are round, the thickness of the oil-film can be reduced. So long as an engine cylinder is not round, a thick oil-film is needed at some points and none at others; consequently, the oil-film is interrupted and wear takes place.

A MEMBER:—Mr. Pomeroy has presented very interesting data in support of his contention that oil viscosity has an important bearing upon engine efficiency, but it is an open question whether these data are representative of actual operating conditions. First, Mr. Pomeroy does not furnish us with the viscosity curve of the oil that he used in his test work; consequently, we are unable to say whether it has a higher internal-resistance than have oils such as would normally be recommended for passenger-car service. Second, under cold-weather operating conditions, when the oil and the water temperatures average low, the oil viscosity is greatly reduced by dilution according to Mr. Pomeroy's own data. From our experience, the percentage of fuel in the oil increases very rapidly; 3 or 4 per cent within 1 or 2 hr. and often reaching 15 or 20 per cent after 100 or more miles of intermittent service.

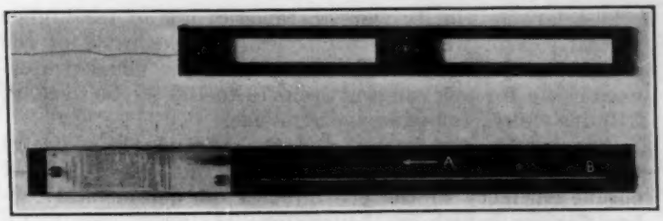


FIG. 1—DEVICE FOR TESTING OIL QUICKLY

The Tube *B* Is Filled with Oil Drawn from the Engine to a Level with the Top of the Slot on the Back of the Instrument and the Tube Is Corked Securely. It Is Important That the Oil in Both Tubes Be at Room Temperature. This Can Be Accomplished Most Certainly by Immersing the Instrument in a Bucketful of Water until Both Tubes Reach or Approximate Room Temperature. The Instrument Is Then Turned Quickly To Be Rightside-Up and Is Held in an Upright Position Steadily While Observation Is Made, through the Slots in the Back, of the Rise of Air Bubbles in the Tubes. If the Bubble in Tube *B* Reaches the Top of Its Slot before the Bubble in Tube *A*, Which Contains the "Master" Oil, Reaches the Top of the Tube-*A* Slot, the Oil Is at or near the Danger-Stage and Should Be Changed. If the Bubble in Tube *B* Has Not Reached the Top of Its Slot before the Bubble in Tube *A* Has Reached the Top of the Tube-*A* Slot, the Oil Has Not Yet Arrived at the Danger-Stage. After Use, Tube *B* Should Be Drained; When Dirty, It Should Be Cleaned with Gasoline, but the Tubes and the Cover Must Not Be Removed from the Instrument. Tube *B* Is Filled by Using an Ordinary Rubber-Bulb Glass-Tipped Syringe

The effect on the oil viscosity of such dilution is very marked; for example, 5 per cent of fuel-ends will reduce the viscosity of the extra-heavy oil shown in Fig. 2 of Mr. Pomeroy's paper to that of the medium oil, while 10 per cent will reduce it below that of the light oil shown. Yet this is less than the average dilution in summer according to the Bureau of Standards' tests.

In actual car operation, the percentage of dilution reaches a fairly well defined maximum, rather rapidly, for any given set of oil and water-inlet temperatures. If these increase as the result of hard driving, the percentage of fuel in the oil will decrease; if they decrease, the reverse will be true.

We therefore feel that, if Mr. Pomeroy had run his tests with oils representative of those actually in use, he would have found that the oil refiners are not so far out of line in their recommendations as his paper indicates. If he would also run tests of engines with mixture-ratios and conditions such as always accompany low-temperature operation in winter, when dilution is most excessive, he would find that the increase in fuel consumption accompanying cold-weather driving cannot be attributed entirely to the increased viscosity of the oil, as his paper would indicate.

It is interesting to contrast Mr. Pomeroy's preference for oils of low viscosity with the views of many European engineers. Not long ago we received the specifications of practically all English and Continental makers of passenger car and other automotive units. These reflected the engineers' preferences regarding the proper grades of

[5] M.S.A.E.—Chief engineer, disc wheel division, Wire Wheel Corporation of America, Buffalo.

oil. A large majority were in favor of oils of far higher viscosity than we ourselves believe are desirable or for which Mr. Pomeroy has shown curves, the usual preference being for oils ranging from 76 to 100 Saybolt sec. at 210 deg. fahr., for passenger-car use.

Apparently, the reason for the attitude is a desire to give the maximum bearing protection, regardless of engine efficiency or the possibilities for detrimental carbon factors, which we believe are of importance along with satisfactory oil distribution and adequate sealing of the poorly fitted pistons and rings we have to contend with.

We agree with Mr. Pomeroy fully that closer cooperation between designing and lubricating engineers is essential, and that much of this must be along the lines of educating the car owner. However, the conditions to which the oil is subjected in the average engine are far worse than they need be. These must be improved before engine efficiency alone can be considered in selecting the correct grade of oil, as Mr. Pomeroy apparently wishes us to do.

A. LUDLOW CLAYDEN:—Tests that have as their object the ascertaining of the condition the oil will be in after it has been used a while are perfectly good but, to the average man, they are meaningless and useless. It seems to me that a help from the standpoint of the shop lies in the establishment of some standard method of treating an oil so that it will be put into something very closely approximating the same condition as would be caused by a very definite period of use. No tests that I know of really do that. A great need exists for a satisfactory method of specifying. I think this is realized by engineers associated with the Bureau of Standards. I look forward to the day when oil specifications will mean something. None of us knows what he wants. We do not know how far we can go in the improvement of lubricants. We believe we are only on the threshold of improvement. I often say that, from the scientific viewpoint, the lubricants of today are in a condition very similar to that of steel say 25 or 30 years ago. At that time we knew a little about some of the alloys, but we had only the vaguest idea why a small percentage of certain alloys changed the physical properties of the steel. With the discovery of microscopic structure-study, many of these mysteries were solved. We want something that will accomplish for lubricants just what this microscopic study did for metals.

Regarding the importance of the nature of gasoline, its only importance with respect to lubrication is its tendency to dilute. The tendency to dilute is very much more affected by the design and workmanship of the engine than by the fuel. In really first-class automobile-engines, the dilution is of the order of from 5 to 8 per cent. In the average automobile, under exactly the same conditions of use, the dilution is from 30 to 60 per cent, despite the fact that the majority of the moderate-priced cars have very much better manifold systems than those of the high-grade machines.

Referring to Mr. Bierbaum's remarks, a study of oil-film thickness in automobile engines is almost impossible. Inasmuch as an automobile engine has very widely fluctuating pressures in all bearings and constantly varying speeds, I believe it would be an impossibility to define the thickness of any oil-film directly. Some definite minimum and maximum might be specified, however.

Mr. Smith and Mr. Gordon also talked about the effect of oil-film thickness. It is generally believed that the safe minimum-thickness of oil-film is very largely determined by the degree of cleanness of the oil. Messrs. James and Midgley and Dr. Dickinson have discussed this. Mr. Midgley stated that, so long as the oil-film is thicker than the largest particle of abrasive in it, no damage will be done; but that as soon as an abrasive particle becomes larger than this, wear will begin. I think that a perfectly logical statement. As to viscosity, from what I have seen I think that 0.05 poise—the poise being the unit of absolute viscosity—is about as low as one needs to go, and that 0.1 poise is about as high as is desirable. At some value between these two limits, provided the oil is clean, one can work with satisfaction.

Concerning Mr. Wier's mention of water in the crankcase, I have conducted tests on the freezing of water there. If water is present in an oil and the oil is run in a crankcase, the water will remain there unless the oil temperature is raised to above 100 deg. fahr.; that is, at any temperature above 100 deg. fahr., the rate of loss of water in the oil is proportionate to the increase of temperature above 100 deg. fahr. Oil at 200 deg. fahr. will lose water twice as fast as will oil at 150 deg. fahr. I arrived at those figures after making many actual engine tests. It is interesting to note that they check very closely with what was already known in the case where water is removed by blowing oil at relatively high temperatures in the presence of air.

Mr. Smith mentioned fatty acids. I think Mr. Pomeroy used the term "fatty acids" in the general mechanical sense. A fatty acid is not an acid at all from the viewpoint of the average man. Its chemical structure is in the nature of acid; but, as to its effect on metals, the reaction is practically neutral.

A very important characteristic of oil about which very little is known is the quality known as oiliness. It has been recognized for a long time that the coefficient of friction of oils containing some animal or vegetable matter is lower than that of pure mineral oils. Recently, this has been found to be due to substances contained in the animal and vegetable matter, and some success has been met with in extracting these substances, which can then be added in very small quantities to mineral oil. The effect upon the mineral oil can be likened to the effect upon steel of adding small quantities of such substances as nickel or chromium.

Oiliness is of no importance where perfect film-lubrication exists; but it is of great importance when the film is imperfect, and it is unlikely that a film will be perfect, at least in piston lubricating. Furthermore, oiliness is of importance when motion is started from rest; and it must not be forgotten that, in gasoline engines, the pistons are stopped and restarted at every stroke.

Oils treated with these substances that reduce their coefficient of friction also, in many cases, give improved durability. The effect of heat and continued use upon an oil is gradually to oxidize it. The rapidity with which such oxidation takes place can be reduced greatly. This line of research has been followed for many years and seems to be nearing a stage where it will begin to be of commercial importance. It may greatly affect the nature of the lubricants that will be used a few years hence.

I was sorry to see Mr. Pomeroy show viscosity curves in which Saybolt readings are used as a basis of plotting. A growing tendency exits, which oil refiners are stimulating as much as possible, toward the employment of absolute viscosity, which is the direct measure of the fluidity of a liquid. The Saybolt and other scales give figures that are not proportional to the true fluidity; for instance, a 400-Saybolt sec. oil is much more than twice as heavy as a 200-Saybolt sec. oil. It is also impossible to compare one type of oil with another by the Saybolt figures, be-

cause variations in the specific gravity affect the Saybolt readings very greatly; but they do not affect the absolute viscosity in any way.

L. H. POMEROY:—The vagueness of the average oil-specification is above all other things irritating to the engineer. He is asked to think in non-technical terms and, all the time, the information about oil that he requires could be translated and made of some value. On the other hand, Mr. Myland complained that it is impossible to tell the engineer anything because he will not listen to reason. Without doubt many engineers, who are at least partly reasonable when dealing with representatives of carbureter, electrical equipment and steel makers, become irritated when told that an oil salesman waits without. I leave it to Mr. Myland to account for this discrimination.

Mr. Round refers to the tendency of the user toward oils of high viscosity. This I think is particularly the case with cars fitted with timing-gears as compared with silent chains, because the high-viscosity oil damps the racket in the front end. As usual, people will pay heavily for peace and silence.

Mr. Ladue, in effect, complains that the engineer wishes to alter the laws of nature. The interference with the laws of nature is the engineer's specific job. He cannot alter them, but he can and does marshal them so that they may be cumulative or subtractive in effect as may be required. For example, without altering the oxygen-content of the air, the engineer has obtained 60 hp. out of a 90-cu. in. engine in which, previously, 30 hp. was looked upon as an excellent result. Surely, improvements of the order of 100 per cent on the part of the engineer deserve some corresponding development on the part of the oil maker.

With regard to oil-film thickness and bearing clearance, I would remind Mr. Bierbaum that the necessities of the case in an automobile engine differ from those in general machinery, because of the change in direction of the bearing loading and the high speeds obtained. It has been shown in England that a 1-in. diameter bearing 2 in. long with 1/16-in. clearance will support an oil-film pressure of some 2½ tons per sq. in., with no measurable wear. But such clearances in bearings where the loading is rapidly being reversed in direction would be impossible. One general aspect of the aluminum connecting-rod and of the aluminum bearing is the increase of the clearance under high-duty conditions, due to expansion, which increases the load capacity of the bearing, on account of the greater thickness of the oil-film and the reduced arc of contact.

Mr. Gordon's viscosimeter is an interesting example of a simple workshop instrument that enables the engineer to separate the sheep from the goats where used-oil is concerned. Its usefulness and its wide field of application are apparent.

Mr. Smith is somewhat doubtful of the use of oils compounded with a small percentage of fatty acids. All I can say is that there is fairly conclusive evidence that such oils are advantageous. As they are now being sold in bulk in Europe, it seems that there cannot be any great disadvantages.

The suggestion made by Mr. Wier of controlling the oil temperature by a thermostat is excellent. This is being done now on at least one French car and, if a simple method of so doing can be worked out, the desired end indicated in my paper will be attained. Not only will friction be reduced, but also dilution due to the natural distillation of the lighter portions of the diluent in the hot oil.

Mr. Clayden remarked on the class of workmanship in general vogue. I think he exaggerates this. While between 15,000 and 20,000 aluminum pistons are being used per day, the automobile manufacturers so doing will not get very far by making cylinder bores that are polyhedral. I wish to voice my appreciation of Mr. Clayden's share in this discussion, which has at least brought out the difficulties with which the oil makers are faced. At the same time, his remarks on my use of Saybolt viscosity-figures indicate that the oil people say one thing in their specifications and think another. My plea is for information understandable by the engineer, in as precise form as possible.

If I were an oil salesman, I should like to be able to say to my customers that the result of using oils *A*, *B*, *C* and *D* would be so and so in respect to internal friction, mileage and the like, not as a pious guess, but as the result of definite experiment made on engines of differing design and class of workmanship, and, if this were thought to be invidious, to be able to say that, in a given experimental bearing approximating in loading and general conditions say a big-end bearing, various oils gave results as indicated. The engineers can then pay their money and take their choice on the basis of some sort of fact, instead of feeling continually that the only way in which oils can be purchased is by straining credulity to its yield-point.

DECEMBER COUNCIL MEETING

THE session of the Council held in New York City on Dec. 5 was attended by President Crane, Vice-Presidents Strickland, Patitz, Pope and Ware, Councilors Brumbaugh, Chryst, Gurney, Hunt and Scaife, Treasurer Whittelsey and W. L. Batt of the Finance Committee, and by H. L. Horning and P. G. Zimmerman, nominees for service on the 1925 Council.

Seventy-eight applications for individual membership were approved. The following transfers in grade of membership were made: From Service Member to Member, D. L. Bacon; Junior to Member, Iskander Hourwich, C. E. Stryker, G. Wedin and L. C. Price; Junior to Associate, I. H. Driggs, W. G. Leamon, Harold E. Morehouse, E. M. Pfauser and H. E. Weber; Associate to Member, J. R. Walsh.

The resignations of 99 members were accepted and the names of five members were stricken from the rolls for default in payment of dues. The reinstatement of 27 members who had previously resigned or been dropped for non-payment of dues was approved.

It was reported that from Jan. 1 to Nov. 30, 1924, 847 applications for membership and Student Enrollment had been received, as compared with 697 applications received during the same months of the year 1923. On Nov. 30, 1924, there were 5428 names on the rolls of the Society, including affiliate member representatives and enrolled students. The corresponding figures for 1923 and for 1922 were 5286 and 5295 respectively.

The following members were named to represent the Society on the Sectional Committee on Safety Code for Brakes and Brake Testing; H. M. Crane, Clarence Carson, C. L. Sheppy and R. E. Fielder. H. E. Blood was named as an additional representative of the Society on the Sectional Committee on Gears.

Maintenance Practice at the Ford Plant

By E. E. Remington[1]

Production Meeting Paper *Illustrated with* Photographs

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

Abstract

MAINTENANCE is the manufacturer's greatest problem. Being non-productive, its cost should be kept as low as possible. Of great importance in keeping the cost low is standardization of the equipment and of the methods of doing the work. Maintenance can best be accomplished by building-up within the plant a live organization that is equipped to meet all conditions and to give service promptly and efficiently. When the maintenance is adequate, good working conditions follow and good results can then be demanded. The greatest efficiency can be attained when all maintenance and construction work is placed under one head. The organization of the Highland Park plant of the Ford Motor Co. is described, in which maintenance includes millwright work, plumbing, steamfitting, painting, glazing, track work, carpentry, tinsmithing and the fabricating shop; in fact, everything except electrical work and machine repairs.

The factory is divided into five territories, each in charge of a competent man who is responsible for all the work in his territory. Two foremen do not cover the same ground. A floating gang has charge of the heavy piping and of the plumbing, tinsmithing and painting throughout the entire factory. The fabricating shop builds everything from the structural steel framework of a building to a stock-box, for all branches of the Company throughout the United States and foreign countries.

Fire protection is provided by service-men who patrol the plant on bicycles every 6 min. When not on duty as firemen, the members of the fire department are engaged in production work in a room adjoining the fire-station. Cooperation between the maintenance department and the heads of other departments is encouraged and lack of it is not tolerated any more than is any other form of disloyalty or dishonesty.

A large number of special devices to assist in maintenance work have been developed, some of which are described in detail. These include hoists for installing lineshafts, trucks, horses, protective netting for the painters, tool-boxes, tool-racks, cabinets for pipe fittings and a belt-cutting machine.

IN analyzing the meaning of the word, I find that maintenance enters materially into the life of every man, woman and child. But we are more interested today in what maintenance means to the manufacturer, and why it is one of his greatest problems. Why is it his greatest problem?

One reason is, that it is non-productive; and this fact means that its cost should be kept as low as possible. How can this best be done? What methods can be applied that will give a high rate of efficiency at a nominal cost? In my opinion, the first move is the building-up of a live working organization, one that is equipped to give service, and to give it promptly and efficiently, an organization that is composed of men of all the different trades necessary to handle any job that may arise. This, no doubt, must be modified to meet the conditions obtaining in a small plant; but, in a large plant, very little work should be contracted for, because better work can be done, and it can be done more promptly and at a lower cost, if it is done on the inside.

Another item that is of great importance in lowering the cost of maintenance is the standardizing of the equipment, such as hangers, bearings, pulleys and the like. This can easily be accomplished and does not necessarily confine one to a single source of supply. It means that the maintenance man and the purchasing department must cooperate in adopting, so far as possible, standards that are of a competitive nature, and create new sources of supply wherever this is consistent with good practice.

Standardization of Methods

Next comes the standardization of the methods to be used in carrying on maintenance work. When an order is given to set a machine, build a conveyor or install a

Fig. 1—Hoist Designed by the Factory Maintenance Department

The Table Which Carries the Work To Be Lifted Is Connected by a Cable to the Lifting Drum. When the Table and the Load Reach the Level of the Platform and It Is Necessary To Raise the Load Higher, This Section of the Hoist Can Be Raised until the Desired Height Is Reached

[1] Superintendent of maintenance, Ford Motor Co., Detroit.

line-shaft, every man should know exactly what material should be requisitioned, and how the work should be done. If this plan is followed carefully, a uniformity of installation will result that will add materially to the appearance of the equipment. A great difference of opinion exists among different companies, as well as among maintenance men, as to what is the proper way of installing equipment and of maintaining the plant in general. This is apparent when walking through or merely driving by a plant. Some evidently think that the less money that is spent on maintenance, the more money will be made; other companies believe in spending sufficient money to maintain their plants properly. I am pleased that the latter is the policy of the company with which I am associated. The real satisfaction of having a plant well painted, with everything in good repair and in good working condition for the men, is in itself a potent argument in favor of adequate maintenance. One is then in a position to demand good results; and nothing can prevent good results from coming from good conditions.

FIG. 2—THE HOIST IN USE FOR INSTALLING A LINESHAFT
The Shaft Is in Place in the Hangers and the Mechanic Is Putting on a Pulley Which Is Supported by the Table of the Hoist

At the Highand Park plant of the Ford Motor Co., all maintenance and construction work, except electrical work and machine repair, comes under one head. This includes millwright work, plumbing, steamfitting, painting, glazing, track work, carpenter work, tinsmithing and the fabricating shop. The factory is divided into five territories, each in charge of a competent man, who is held responsible for all the work done in his territory. We find that this method simplifies the work considerably because two foremen do not cover the same ground. All repairs to equipment and the installation of new equipment are taken care of by men in these territories. This plan enables us to check the work of each foreman with that of other foremen by comparing their methods and the time required to do certain kinds of work. Heavy

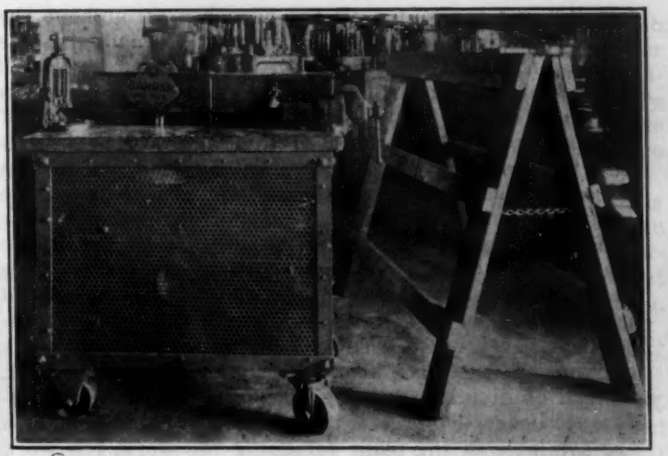


FIG. 3—THE STANDARD TYPE OF HORSE USED IN THE FORD PLANT
This Horse Supplements the Hoist Shown in Figs. 1 and 2 and Is Used in Places Where the Hoist Cannot Go. The Floor Space Occupied Is Approximately 2½ x 4 Ft. A Chain Prevents the Horse from Spreading when a Weight Is Placed on the Top and the Collapsible Feature Enables It To Be Handled Readily. The Truck at the Left Is a Special Type that Has Been Developed for the Steamfitters and the Millwrights. The Standard Tool-Boxes, Two of Which Can Be Seen on Top of the Truck, Are Placed in the Truck at Night

piping, plumbing, tinsmithing and painting are taken care of by a floating gang that covers the entire factory.

THE FABRICATING SHOP

One of the most interesting departments in the maintenance organization is the fabricating shop. Here is built everything from the structural steel for a building to a stock-box. All equipment, such as conveyors, ovens,

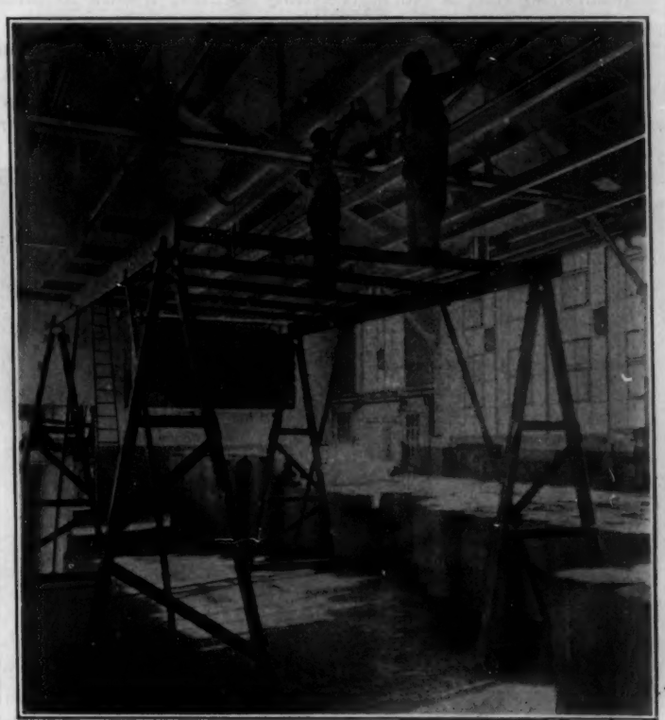


FIG. 4—ANOTHER TYPE OF HORSE
This Is Used Primarily for Painting, but Can Be Employed for Other Work, although It Is Somewhat Light for General Millwright Work. The Horse Is of the Extension Type and Enables the Platform To Be Raised from 7 Ft. with the Horse Closed to 14 Ft. When It Is Fully Extended. The Planks Used by the Painters Are 2 x 8-In. Yellow Pine, Entirely Free from Knots and with a Bolt through Each End. A Clamp Similar to That Used in Body Work Serves To Fasten the Cross Braces in Place

benches and tanks, for all the branches throughout the United States and foreign countries, is made in this shop. An average of 30 tons of steel is used daily. All equipment is standardized. If a conveyor or an oven is made for the Memphis branch, having a capacity of 500 cars per day, an oven of the same size will work and will be built for Manchester, England, or Buenos Aires, if the same production is wanted; or it will be lengthened or shortened to meet the requirements.

You may ask whether it is practicable to handle the maintenance of a large factory with one maintenance head. I would say, yes, and my reason is, that one head is wholly responsible for everything in the line of maintenance. If there are several maintenance heads, it is only natural that each head will look after his own work, instead of dividing the men efficiently with other maintenance heads. The result is that, although plenty of men are available in the plant for doing the work, the work is not done because the men are not used where they are needed most. In my opinion, no plant is too large to be maintained by one maintenance organization; and the cost is much lower with a single organization than with two or more.

Service and Firemen

When he is on night duty, every minute of a serviceman's time should be spent in patrolling the plant, in preventing fires from starting, and in detecting air, steam, water or gas leaks. An hourly patrol for preventing fires is wrong, because a fire then has a chance to get beyond control before being discovered. At the Ford plant, the main buildings are patrolled every 6 min. by patrolmen on bicycles, which has been found to be very practicable. The men pull the boxes at certain points, so that a clerk, centrally located, knows at once whether a watchman is failing to cover his beat.

The fire department is centrally located. Twelve men are on duty at all times and, when not on duty as firemen, are engaged in production work, in a room adjoining the fire station, in which are vertical drilling and other

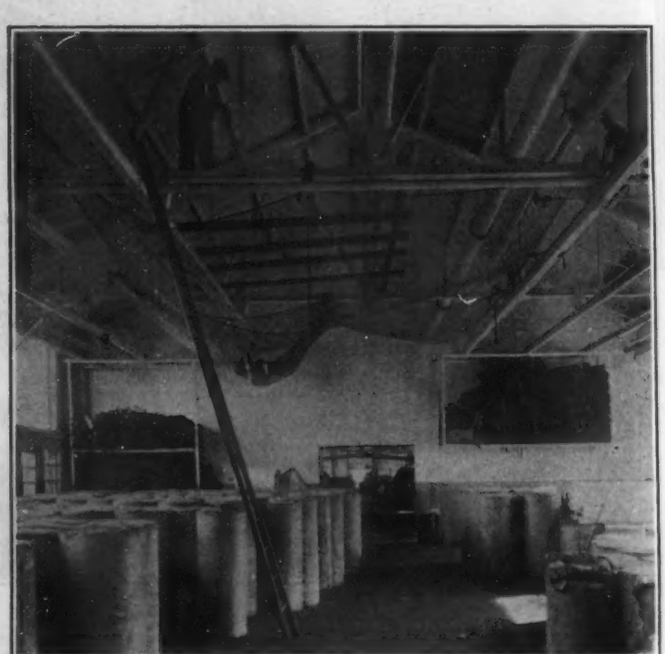


Fig. 5—Use of Safety Nets in Painting
These Nets, Which Are 20 Ft. Square, Greatly Resemble a Fish Net. Their Use Gives the Men a Sense of Safety and Results in Increased Output. The Truss Is Approximately 25 Ft. from the Floor and the Man in the Net Has Fallen 10 Ft.

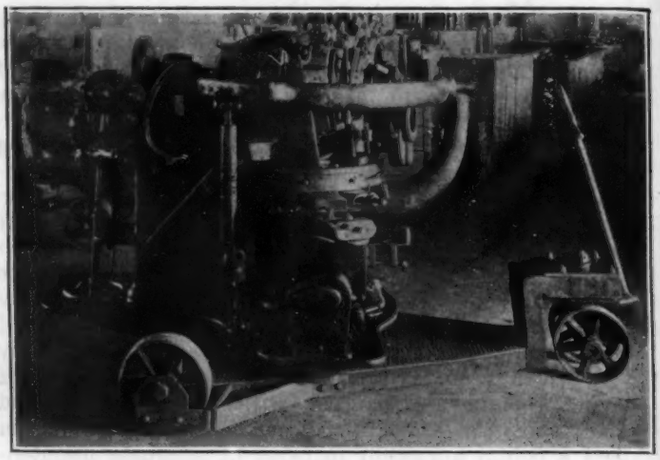


Fig. 6—Truck Used for Moving Machinery
Each of the 15 Gangs Who Do Nothing but Move Machinery and Do Gin-Pole Work Has a Truck. In the Last Year about 9200 Machines Were Moved and Only 8 Were Damaged

machines. This system seems to have worked out very well. During the 12 years that I have been with the Ford Motor Co., I have not known of a serious fire. Some of the overhead expense of the city fire department might be carried in some such way and at the same time be a good thing for the men.

One thing that is essential in handling the maintenance of a plant is the developing of a spirit of cooperation between the maintenance department and the heads of all the other departments, as well as with the superintendent. Every man in authority in a plant should feel that, if he has a problem to solve in the way of bettering the operation of some equipment or the working conditions of his department, he has a friend in the maintenance department, which, in turn, should feel that it is its duty to attend to such wants. When cooperation is lacking, the time lost and the money wasted cannot be estimated. I believe that it should not be tolerated any more than any other form of disloyalty or dishonesty.

Special Equipment

Some special equipment has been developed for taking care of maintenance work. Installing lineshafts entails considerable hard work. In Fig. 1 is shown a special type of hoist for this purpose. The table is connected with a drum that lifts the work by a cable. The table, carrying a load, is raised until it strikes the platform. If it is necessary to raise the load higher, when the table strikes the platform, it starts the second section, and that section can continue to rise until the table reaches the top. Fig. 2 shows a pulley being installed on a lineshaft by the use of this hoist.

A wooden horse is used in places into which the machine cannot go. It is collapsible, its legs are prevented from spreading by a chain, and it can be slipped between machines where the space is very narrow.

This standard horse that is used throughout the shop is illustrated in Fig. 3. This appliance, although practicable when new construction work is being installed or when used in an open place, cannot be used when machines are close together. The base is about 4 ft. by 30 in.

Another standard horse, used in painting, is shown in Fig. 4. It is also used on other work but is a little light for general millwright work. It is of the extension type, so the platform can be raised to a height of from 7 to 14 ft. It is readily erected and has a special brace and clamp. A 2x8-in. beam is used as a cross-

piece. The planks used by painters are of yellow pine, entirely free from knots, and have a bolt through each end. The cross-braces are put on with a bolt similar to the clamp used on body work.

Netting

In Fig. 5, some painters are painting a truss that is about 25 ft. above the floor. Below them is stretched a net, made very much like a fish net, about 20 ft. sq. The

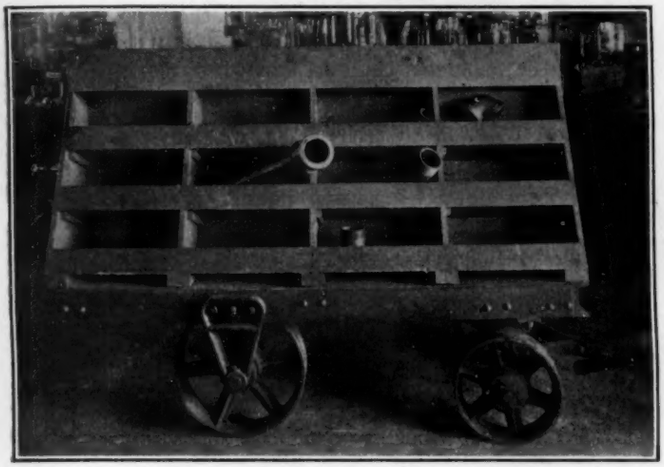


Fig. 7—Special Pipe-Fitting Truck
When Pumps Have To Be Connected as a Result of Moving a Department or the Pipe-Lines Are Changed, the Different Fittings Required Are Deposited in the Various Compartments, One Being Used for Each Size and Type of Fitting. When the Truck Is Fully Loaded a Tractor Pulls It to the Location where the Work Is To Be Done

quantity of netting is sufficient to protect 15 or 20 painters at one time. The nets give the men a sense of safety; consequently they do much more work. When this photograph was taken, an opportunity was presented for some fine moving picture work. Desiring to obtain a picture of some one in the net, we asked one of the men to get into it. He was standing on the plank and simply fell over backward, striking in the net just as you see him. That act demonstrated the feeling of security that the men have when the net is below them. Where the man is lying is about 10 ft. below the plank.

A truck that is standard with us and is used exclusively for moving machinery is shown in Fig. 6. On it is a Gleason gear-cutting machine. If you have ever had to handle one of these machines, you know how difficult it is to handle it. In our plant, 15 gangs do nothing but move machinery and do gin-pole work, raising, hoisting and the like. Each gang has a truck.

Skill in Moving Machinery

In the first 9 months of 1924, 9200 machines have been moved. The men are experts at handling machinery. Rollers of different sizes are used with this truck. In the illustration, a 5-in. roller has been rolled back out of the way. That size of roller is used for putting this machine on the truck or, for that matter, for putting any machine on the truck, because the platform of the truck is about 5 in. above the floor.

In the last year, those men have broken only 8 machines. When one considers the number of machines that have been handled, one can see that the men are a pretty level-headed group. Many of the machines have been moved from the fourth to the sixth floor by cranes. Some of the machines are so heavy that two cranes must be used because, in our building, 5 tons is the limit of the capacity of the cranes.

We have at least 200 Bullard machines, many of which are on the sixth floor. That means that an equalizer and two cranes must be used to handle one of the machines and land it on the balcony. Some of them are too large to handle on a 15-ton truck. Fifteen tons have been handled by one truck, but a Bullard machine it too large in circumference to be put on it.

The truck is about 5 ft. long. A long lathe will hang over, but the men are so expert they can "wrestle" with any kind of machine. If a machine is too long and overhangs the truck, two or three men stand on the front end of the truck to balance it, a tractor comes along, picks them up and away they go to their destination.

Compartment Trucks for Pipe Fittings

In Fig. 7 is a little truck that was made in the plant. The back is similar to the front. Suppose a department must be moved. Those of you who are in the larger factories or have visited the Ford plant know what it means to move a department. Take, for instance, a department performing only one operation. With the mass of production in our plant, moving a department may mean moving 40 or 50 machines, perhaps 100 or 150; the steamfitters and the pump men must connect up the pumps, and a great many fittings are required. The fittings are requisitioned; the stock-chasers deposit the different sizes of fitting in the different compartments of the truck; then a tractor takes the truck to the department. Whenever a man needs a fitting, he goes to the truck. Fittings are not lying on the floor. The com-

Fig. 8—Machine Used in the Belting Stockroom
A Piece of Steel on the Floor with a Brass Tack Inserted Every ½ In. Serves as a Yardstick. The Free End of a Roll in the Background Is Pulled Out along the Floor to the Required Distance and the Belt Is Cut to the Proper Length. The Use of This Arrangement Has Done Away with Small Pieces of Waste Due to Improper Cutting, Which Averaged almost $23 per Day before the Machine, Which Cost between $12 and $15, Was Purchased

(*Concluded on p. 91*)

Improved Nickel-Plating Methods

By W. H. Graves[1]

Production Meeting Paper

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

ABSTRACT

A PRACTICAL method of nickel-plating is outlined and the various processes are described by which the Packard Motor Car Co. has been successful in producing a durable coating of nickel on automobile parts in general, and the radiator shells, the rim plates and the tire-carrier plates, in particular. These are the parts of greatest exposure, and for plating them a new system of moving-cathode tanks was installed.

The three problems to which special attention was devoted were rusting, pitting and peeling. No effort was made to secure a coating of any designated depth but reliance was placed solely on the results indicated by a 24-hr. salt-spray test, which was considered to be the equivalent of 2 years' exposure to the usual weather conditions. Peeling was overcome by thoroughly cleaning the parts before plating.

New equipment was purchased and laid out in accordance with the system decided upon, namely, copper-plating, buffing and nickel-plating. The complete process comprises the six stages of (*a*) polishing, (*b*) cleaning, (*c*) copper-plating, (*d*) buffing and cleaning, (*e*) nickel-plating and (*f*) buffing. Each of these steps is described in detail.

The advantage of the moving-cathode tank is said to lie in the fact that it has a definite time-cycle, and in the ease with which the current can be controlled. The saving of solution that may be effected will depend largely on the volume of production. By having all the shells pass the same anodes, compensation is obtained for the wearing away of the anodes, and the slight agitation produced has a beneficial effect on pitting.

Although informed previously that a high current-density could not be used, the current was increased from 2 to 25 amp. As the cycle is 17 min., the total current consumption is about 425 amp-min. The effect has been that more copper is deposited and more quickly; the shells also withstand from four to five times as long a test as they endured under the old method of plating. Thorough buffing is said not only to improve the resistance to rust but to improve the appearance of the plating.

In the nickel-plating process, the solutions are contained in moving-cathode tanks, similar to those used in copper-plating, and the current was increased from 2 to 11 amp. During 40 min. the shells receive 440 amp-min. of current.

Solutions are not filtered but are kept clean by controlling the acid-content; sludge settles to the bottom of the tank and gives no trouble. A final washing and buffing completes the process.

The most important rules to be observed, in order to obtain successful results, are summarized under the heads: careful polishing, thorough cleaning, plenty of copper, buffing, another cleaning, plenty of nickel and accurate control of solutions.

THEORIES of the deposition of metals are about as numerous as those of any other scientific problem. But the way in which we have attacked this problem is practical rather than theoretical or scientific. This paper is merely a statement of what has been accomplished at our plant to improve the nickel-plating processes.

The three problems that we endeavored to solve were (*a*) rusting, (*b*) pitting and (*c*) peeling. The worst one was rusting. Radiator shells, in particular, rusted badly, and without much exposure assumed a bad appearance. In addition to this, pitting of the nickel occurred in production. Every plater knows this problem; and we had it to contend with. Peeling also caused trouble, but was not hard to overcome after the right processes had been discovered.

The first step in solving these problems was to find out what improvement was necessary; but, before that could be done, some kind of test had to be worked out to determine what progress was being made. For rusting, the salt-spray test described[2] at the meeting last year was used. In a monel-metal box a 20-per cent salt-solution is atomized with a glass-tube atomizer. In this salt vapor are placed the parts. The box is large enough to hold two radiator shells and a large number of small parts at one time. A little valve, like that on a gasoline line, controls the air. If more pressure is desired, the valve is opened; if less, it is turned off. The salt solution at the bottom of the tank is sucked up through two glass tubes that were made in our laboratory. They are drawn to a point, one tube standing upright, the other crosswise. Air-pressure through the horizontal tube draws the solution through the vertical tube and atomizes it so that it completely surrounds the work.

Importance of Thorough Cleaning

We recommend a thorough cleaning of a piece before submitting it to the salt-spray test. To take off any finger-prints that may remain on them, all the shells are washed with gasoline before being placed in the spray. If a piece were greasy when placed in the salt spray, probably no rust would appear.

When we began the test work, radiator shells were coming back from service badly rusted; but that effect could be duplicated with about 18 hr. of salt spray. In other words, we estimated that 12 hr. of salt spray was equivalent to 1 year, and 24 hr. to 2 years, or about 1 hr. to a month. This does not take into consideration the nickel that might be rubbed off when the shell is polished. The sides are the places that give the most trouble in service. Salt-spray tests run fairly uniform. Rust spots appear occasionally in fewer than 24 hr. but a shell seldom breaks down before that time unless the break is caused purely by a defect that can almost be seen with the naked eye.

No particular thickness of copper or of nickel is sought. The actual quantity that is deposited is considered immaterial. The salt-spray test was adopted to tell whether the amounts of copper and nickel that had been put on were sufficient to prevent rusting; and we depend on the test.

Working out a test for the prevention of peeling was rather simple. In fact, peeling is usually caused by rust

[1] Chief metallurgist, Packard Motor Car Co., Detroit.

[2] See The Journal, February, 1924, p. 127.

or by grease that has not been removed from the part before plating. The foreman of our plating department worked out the system of always dipping a shell into cold water before placing it in either the copper or the nickel solution. If the water film does not break, the indication is good that the part is free from grease. It is very easy to train men to observe this test, so, in production if the film does not break when the shell is taken out of the cold water, the shell is considered clean enough for the next operation.

Improvements In Equipment

New equipment was the first step in improving the nickel-plating. All the old equipment was thrown away and new equipment was purchased. The layout was made after we had decided on the method to be used, which is, briefly, copper-plating, buffing and nickel-plating.

All the plating tanks are made of wood, pitch-lined, and are away from the floor. The top is about 5 ft. from the floor-line. The lattice work where the men work is 30 in. above the ground.

The plating tanks are of the usual moving-cathode type. The reason for adopting this type of tank is first, that it has a given time-cycle. With the old-style tanks, it was very hard to keep the shells in the solution for the same length of time. One would be forgotten or, perhaps would remain in the tank too long or be removed too soon. Now, all the work remains in the tank the same length of time.

The second advantage is the ease with which the current can be controlled, so that each shell will get the same amount. If 19 shells are put into the tank, the current that each one receives is the same as if only one were put in. The current can be changed at will. Controlling the current is much easier than formerly, because the men know how many shells are in the tank; if they put in another one, they raise the resistance; if they take one out, they decrease it.

The saving of solution that may be made by using moving-cathode rather than still tanks will depend largely upon the amount of production. The number of tanks formerly in use was the same as that in use now. If the volume of production is sufficient to warrant continuous operation, a moving-cathode tank will be better than a still tank but, with a large volume of miscellaneous work, more solution will be tied up.

Compensation For Anode Wear

As the anodes wear-down, the depth of plating becomes less; when an anode is brand-new, the deposition is stronger than when the anode is small. By having all the shells pass the same anodes, compensation is obtained for the wearing away and more uniform results are secured. A slight agitation is also produced that seems to be very satisfactory. Previously, there was no agitation. The slight agitation has alleviated some of the pitting trouble.

Although all kinds of plating are done at our plant, moving-cathode tanks are used only for the shells, the rim plates, and the tire-carrier plates. For other parts, barrel-plating or still tanks are used, with the same current-densities and the same solutions as in the moving-cathode tanks. The intention was to put in more barrel-plating tanks but we were told that the process was not good; that the plating would be worn off as fast as it was applied. We then tore out all the other equipment and went to work on barrel-plating. Finding first that the motor-generator set was not large enough to give high current-density, we purchased a new one, which improved the barrel-plating considerably. Although the results after the 24-hr. test are not so good as they are when the highly polished shell is tested, they are excellent. Some rust appears on the threads, but the exposed surfaces are almost entirely free from it. Previously, 4 hr. of exposure would have rusted the parts so badly that they would have been useless.

Process of Nickel-Plating

The nickel-plating process consists of six stages: (*a*) polishing, (*b*) cleaning, (*c*) copper-plating, (*d*) buffing and cleaning, (*e*) nickel-plating and (*f*) buffing.

The polishing operation is done in a room entirely separate from the plating. Real quality in nickel-plating begins with the polishing. The surface of the part to be plated must be smooth. If polishing-marks are left, when the buffing is done later, the copper and the nickel will be cut off and some rather serious difficulties will be encountered. The polishing process comprises five operations: one with the No. 70 emery, one with No. 120 and three with No. 150. These operations are carried on at varying angles as follows: No.-70 wheel, at approximately a 30-deg. angle with the horizontal plane; No-120, at right-angles to the first; the first No-150, at approximately a 30-deg. angle with the horizontal plane; the second No-150, at right-angles to the first No-150 polish; and the final No-150, at approximately a 30-deg. angle with the horizontal plane. The last No-150 polishing is done with a wheel worn well down, with no sharp corners, so that it will make no scratches. Many persons use much finer wheels; but the sizes described have been found to be excellent for controlling the polishing, and the wheels do not have to be resurfaced so often.

Next is the cleaning. We use an electric cleaning-bath, 4 oz. of Wyandotte cleaner per gallon of water being used in a 500-gal. tank at a temperature of from 180 to 200 deg. fahr. This process requires about 3 min. with a current-density of 10 amp. per sq. ft., the work being used as the cathode.

From there the piece goes into the cold water again and is washed, then into the muriatic acid, which is simply a neutralizing solution, back to the cold water again, then into the sodium cyanide, then it is bench-brushed with pumice. A regular plater's-brush and pumice are used and particular attention is paid to the corners. Then the piece goes back into the cold water, and is inspected for the water-film breakage that I have mentioned. If the piece comes out clean and the film does not break, it is considered ready for the copper-plating solution.

The muriatic-acid pickle consists of a 10-per cent cold muriatic-acid solution contained in a 100-gal. lead-lined tank. The purpose of the sodium cyanide is to neutralize any muriatic acid that may remain on the piece. The concentration, about 3 oz. per gal. of water, does not do much harm when it gets into the water, yet is strong enough to remove the acid.

All the cold-water rinsings are made in the same tank, into which water is continually flowing, but the water is changed so often and the shells go through so slowly that no trouble has been caused by the rinsings' being carried over into subsequent plating operations.

Copper-Plating

The copper-plating tank is a moving-cathode tank, in which the current-density is 25 amp. per sq. ft. On the Six shells, which are a little smaller than the Eight,

the amperage is about 30, because of the capacity of the motor-generator set that is used. As the cycle is 17 min., the total consumption is about 425 amp-min., a quantity considerably greater than that used in the general practice. Some plants that we visited use from 60 to 182 amp-min. Others may use more but, if they do, we did not discover it. As the tank is about 10 ft. long, the rate of cathode movement is about 1.7 ft. per min.

With a high ampere-minute rate more copper is deposited and it is deposited more quickly, the amount of deposition being dependent strictly on the number of ampere-minutes. Whereas, we formerly used 2 amp. per min. per sq. ft. for 17 min., we now use 25.

Our platers used to say that it was impossible to use so high a current-density but, although the new equipment increased the current-density, we had practically no trouble. The results were excellent. It was necessary only to increase the concentration of the copper solution, a very simple thing to do. When the shells were tested in the salt spray, we were very much gratified to find that they withstood from four to five times as long a test without rusting as they had endured under the old method of plating.

The copper-plating solution consists of 850 lb. of sodium cyanide dissolved in cold water, to which is added slowly 950 lb. of copper cyanide; and the solution is stirred until the copper is dissolved. This solution is placed in a 2000-gal. steel tank, 530 lb. of sodium carbonate, dissolved in hot water, is added, and the solution, diluted to 1700 gal., is held at a temperature of from 150 to 160 deg. fahr. during the plating operation. The piece to be plated is suspended on copper hooks 8 in. from the anode, the face of the piece being toward the anode. After the piece has been removed from the plating solution, it is rinsed in cold running water, then in hot water and is air-dried. The copper deposit must not curl or chip, and must be free from blisters and of sufficient depth to withstand cutting down in the buffing process without cutting through.

The composition of the copper solution now in use is given in Table 1.

TABLE 1—COMPOSITION OF COPPER SOLUTION

Copper, oz. per gal.	4.5 to 5.5
Free Sodium Cyanide, oz. per gal.	0.2 to 0.5
Sodium Carbonate, oz. per gal.	5.0 to 8.0
Current-Density, amp. per sq. ft.	25.0
Voltage	4.0 to 6.0
Temperature, deg. fahr.	150 to 160
pH Number	High

BUFFING

The next operation is buffing. This is done entirely by hand and is considered very important for several reasons. First, it makes possible the smoothing-down of the surface and the filling-up of little imperfections in the steel. Although an effort is made to get a very smooth surface in the first polishing operation, some polishing-marks and pits are left in the steel but, in the buffing process, these little imperfections are smoothed over and filled up and the high spots are cut off. Experience has shown that buffing the copper makes a material difference in the quality of the finished plate in two respects: (*a*) resistance to rust and (*b*) appearance. This is true particularly if the surface is not smooth to begin with. Luster has much to do with durability, the theory being that any polishing-marks that may have been left after the first polishing of the steel will be filled by the copper and the nickel will cover any steel that may have been exposed. On some shells, the polishing-marks can be seen through the nickel. If these marks are examined carefully after the salt-spray test, rust will be seen to have appeared first on the top of these marks. A spare-wheel lock that had not been polished satisfactorily, would break-down very quickly when put through the salt spray. It was not until a better surface had been put on that the results improved. The method of plating was not changed at all; the better finish and the buffing of the copper merely helped to take out the imperfections that had been left from the original polishing operation.

After the buffing operation, the shells go through the same cleaning operation as before, with the exception of the muriatic acid, hot water being used to dry them before they go to the buffing-room. When they come back, they are cleaned by passing through the electric cleaner again; then they go through the cold water, to the cyanide, back to the cold water, where they are inspected with the film-test again, and then into the nickel tank.

NICKEL-PLATING

The same type of moving-cathode tank that is used in copper-plating is used in nickel-plating; and the current-density has also been increased, a feature that we believe to be responsible for the improvement. The amperage in the nickel tank could not be raised as high as that in the copper tank for two reasons: First, the motor-generator that was in use would not give sufficient current; and secondly, a few difficulties were encountered even with the current that was available. We now use 11 amp. per sq. ft., however, where we used only 2 amp. per sq. ft. previously. This is an increase of 550 per cent.

After the 2000-gal. wooden tank has been half-filled with water, 875 lb. of double-nickel salts dissolved in hot water is added, 3500 lb. of single-nickel salts and 250 lb. of sodium chloride are dissolved in it, and the solution is diluted to about 2000 gal. Two hundred fifty pounds of boric acid dissolved separately is then added.

The shells are left in the tank for 40 min., which means that they receive 440 amp-min. of current, the deposition there being the same as in the copper tank. Others use from 60 to 80 amp-min.

In nickel-plating, either a single or a double-salt solution may be used. We have both in our tanks, the average being about 7 to 10 oz. of double salts and 23 to 25 oz. of single salts to the gallon. The solutions are cold. If the solutions should become alkaline, the acidity is maintained by adding boric acid. The maximum free-acid content of the electrolyte in the nickel tank, known as the *pH* number, obtained by the Double Wedge comparator, is 5.6 to 6.0.

SLUDGE

Controlling the free-acid content keeps the solution pure, but whether it will prevent sludge from forming at the bottom of the tank will depend on the purity of the anodes. The sludge settles to the bottom of the tank and the circulation is not sufficient to give trouble. The solutions are not filtered but are kept clean by controlling the acid-content.

Solutions are controlled by the laboratory rather than by the plating foreman. Specifications cover all the details and the solutions are analyzed weekly, but meanwhile, if anything happens, the plating foreman has the privilege of coming to the laboratory and having a special analysis made. The solution is checked for the

nickel-content, which is maintained at from 5.0 to 5.5 oz. per gal., and for the acid, or *pH*, number.

The composition of the nickel solution at present is given in Table 2.

TABLE 2—COMPOSITION OF NICKEL SOLUTION

Double-Nickel Salts, oz. per gal.	7.0 to 10.0
Single-Nickel Salts, oz. per gal.	23.0 to 25.0
Sodium Chloride, oz. per gal	2.0 to 3.0
Boric Acid, oz. per gal.	2.0 to 3.0
Current-Density, amp. per sq. ft.	11.0
Voltage	4.0 to 3.0
Temperature	Room
Time, min.,	40.0
pH Number	5.6 to 6.0

After coming from the nickel tank, the shells are washed and buffed again. The advantage of high current-density lies principally, of course, in the preventing of rust. The water tests are worked in between times simply to prevent peeling. This process has reduced by about 88 per cent the expense of replating, because previously great care had to be taken that the buffing did not wear through the copper and the nickel. A shell now has very rarely to be recoppered or renickeled because of the wear of buffing. This is largely because much more copper and nickel are put on. Formerly, a little 10-in. wheel was used and caution had to be exercised not to hold the shell too tightly against the wheel; now, a 14-in. wheel is employed and the work can be done not only better but much more quickly.

I have brought with me a shell that was plated yesterday and has been in the salt spray for 24 hr. The rust on the inside is negligible. On the outside, no sign of rust is visible, and the shell is considered satisfactory. Under the old process, considerable rust would have appeared after 4 or 5 hr. and an exposure of 24 hr. would have produced rust over the entire shell to the same extent that it is now on the inside.

Essentials of Good Nickel-Plating

The rules that we believe to be the most important in producing a good nickel-plating process are:

(1) Be sure that the surface is polished smooth
(2) Get the surface clean before beginning any of the plating processes
(3) Put on plenty of copper
(4) Buff the copper
(5) Be sure that the surface has been cleaned well again before nickel-plating
(6) Be sure to put on plenty of nickel
(7) Know the composition of the solutions. If you do not know what the nickel-plating solutions are, you cannot get consistent results

THE DISCUSSION

QUESTION:—Has the Packard Company done any experimenting in plating zinc instead of copper under nickel?

W. H. GRAVES:—No.

QUESTION:—The inside of the shell was in the plating tank as long as the outside; why should it rust more easily?

MR. GRAVES:—In the first place, the inside is not polished, and, as I have pointed out, good polishing is one of the important factors in getting a good job. The copper is put on but is not buffed, nor is the inside cleaned very well. These three reasons are the cause of the rusting.

A MEMBER:—What thickness of nickel do you get per square foot, not theoretically? In explaining that question I should like to say that in depositing nickel I have always found that, if you take a square foot at the top or at the bottom of the shell, you will get much more nickel at those points than on the sides of the shell. If you do not make a test of the different parts of the shell, you will not know how soon it will break through in a weak spot. The weakest link is the strongest link in the chain and the weakest spot on that shell is the strongest spot when it is out in the weather. I believe that to control the strength you should know what is the weakest point.

MR. GRAVES:—We pay no attention to the actual thickness of nickel on our shells; we go entirely by the salt spray for testing. We run the shells through the tanks with the face of the shell toward the anode, so that the nickel will be deposited more heavily on the wearing surfaces.

CHAIRMAN F. A. CORNELL:—I have had occasion to travel considerably and to see many platers. I appreciate particularly the words "not theoretically" in the question because I have never yet found, by actual micrometer test, that films of plate that had been deposited checked with the claim made for their thickness.

A MEMBER:—I think it is not possible to check them. A certain resistance must be overcome in the solution, theoretically, but the actual deposit that is obtained is a different thing. You cannot say that, because an ammeter indicates 50 amp. per sq. ft., the thickness of the deposit can be determined. It will not hold true.

MR. GRAVES:—I think there is no doubt that 440 amp-min. will put on more nickel than will 50. I do not mean to say that that statement will hold right down to the actual measurements of the piece, but certainly more nickel will be deposited with that many ampere-minutes than with a smaller number. Do you not agree?

A MEMBER:—Yes. You will find an immense variation between the top and the bottom and the sides of the shell.

CHAIRMAN CORNELL:—Is it not because of the nearness of the edges to the anodes?

A MEMBER:—I think it is because electricity takes the shortest path.

MR. GRAVES:—If the anodes are as long as the piece, the carrying capacity at the bottom will be nearly the same as at the top, but it will not be the same across the piece.

A MEMBER:—The current goes around and then across. Instead of breaking off in the center of the anode, electricity takes the path of least resistance and follows the anode until it reaches the bottom; then it shoots across the tank in a kind of wave.

MR. GRAVES:—We run our shells with the top down in our copper baths to offset to some extent just what has been mentioned. However, we can go back to the salt spray again if we are not getting proper results. We feel that if we have 24 hr. in the salt spray, we shall have a good-wearing piece of nickel.

A MEMBER:—Twenty-four hours of salt spray may indicate a good coat of nickel, yet, when you think that a zinc coat is expected to endure from 60 to 75 hr., it does not seem to me that 24 hr. is a long test at all in salt spray. It would not pass the Government specifications. I am still speaking comparatively. Zinc is deposited at a greater rate than is nickel. I do not believe that you have a very thick coat of nickel, notwithstanding. I do not think that 24 hr. will assure a good piece. I was in a plant at Detroit recently where they were considering the installation of just such a layout

as you have; they insisted on 50 hr. in the salt spray, to give what they considered to be a good coat of nickel.

MR. GRAVES:—I should like to see some of it on a shell. Fifty hours might not be too long for a little piece but it is a long time for a big shell, and we believe impossible.

QUESTION:—What can you tell us about using a plating of zinc, copper and nickel on steel or iron?

MR. GRAVES:—I do not know anything about that combination. We have not done any work on zinc-plating. Our plater tells me that it is impossible to get the good finish that the inspection department demands over zinc. I do not know whether he is right.

QUESTION:—What methods have been used and what results have been secured in plating aluminum and aluminum alloys?

MR. GRAVES:—Very poor; we have had some terrible experiences and have decided that we shall stop. Headlamp rims made of aluminum corroded very badly. Two or three other parts did the same. We have had to change the material in our head-lamp rim to a rolled brass. Whenever we tried to nickel-plate aluminum, we met only with failure. We try to specify materials other than aluminum when we want a nickel-plated finish.

QUESTION:—Why did you discard cadmium-plate before nickel?

MR. GRAVES:—Because we could not get the cadmium to spread over the entire shell. We spent a large amount of money but we could not get cadmium to plate the whole shell.

CHAIRMAN CORNELL:—In other words, the objection to cadmium is lack of spread?

MR. GRAVES:—Yes; that was the main trouble.

L. K. SNELL:—What effect does the strength of the current have on cadmium-plating?

MR. GRAVES:—The platers tried to use as high a current-density as they could. They raised it to 60 amp. or more; the current would not carry the whole width of the shell.

MR. SNELL:—The reason I ask that question is that I did some experimenting at a plant with which I was connected at one time, and we failed because we were not able to supply enough current to the plating solution in our equipment to satisfy the company that was introducing the cadmium-coating; so we gave it up for the time being.

QUESTION:—What would be the effect if the last two polishing operations were omitted and a heavier copper-plate were applied to compensate for them?

MR. GRAVES:—It would not be very good. We use a pretty course emery. If we left out the two polishing operations, the result would be poor.

E. T. CAUSER:—My idea was to give them a heavier copper-plate that should fill up any scratches that might be in the shell. Would not the heavier copper, say 10 min. longer in the copper solution, fill up any defects or so-called scratches?

MR. GRAVES:—Partly; but the copper follows the contour of the metal and is deposited on the top as well as on the bottom of the crevices. Buffing it will cut off the top.

MR. CAUSER:—Your idea is, that you are buffing it smooth so that it will not be so bad?

MR. GRAVES:—Yes.

MR. CAUSER:—In other words, it rolls the metal into the so-called cavities?

MR. GRAVES:—It takes it off on the top and fills up the cavities.

MR. CAUSER:—Would not a little heavier copper have that effect.

MR. GRAVES:—If you are not going to buff, you will still have the problem of heavy metal on the high spots.

MR. CAUSER:—It might be well worthwhile trying. I might say that I have been very successful in that very thing.

MR. GRAVES:—What current-density and what time do you use?

MR. CAUSER:—About 18 to 29 min. in the copper solution.

MR. GRAVES:—What is the current-density?

MR. CAUSER:—I cannot give that. We run 17 min. in our copper-striking coat after the first copper coat has been buffed.

QUESTION:—What is the time of the copper-striking coat after the first copper coat has been buffed?

MR. GRAVES:—We do not copper-strike after buffing. We put the nickel on directly.

QUESTION:—What anodes do you use, the electrolytically pure anode or the anode alloyed with iron?

MR. GRAVES:—The commercial anode.

QUESTION:—Do you mean the cast anode?

MR. GRAVES:—It is 95-per cent pure.

CHAIRMAN CORNELL:—They are deposited by electrolysis. The cast anode, if I am not mistaken, is one that is alloyed with between 4 and 5 per cent of other metal to make it more malleable.

A MEMBER:—I know that the Packard Company within the last year was using all cast anodes and that Packard was using an anode that did not run more than 95-per cent pure. If he used an anode that contained 95 per cent of nickel, he certainly had 1½ per cent of iron in the anode, plus copper and the like.

MR. GRAVES:—We use a standard cast-nickel anode.

A MEMBER:—I believe that the cast anode forms sludge. You can get rid of the discoloration caused by the iron in the solution by adding sulphuric acid. The question is, how far can one go before doing harm?

MR. GRAVES:—I am sure that we do not use sulphuric acid today. By controlling the *pH* number, the sludge was kept at the minimum.

QUESTION:—Have you used a 5-per cent salt solution in salt spray?

MR. GRAVES:—No. Twenty per cent is the standard of the Bureau of Standards and we have always used it.

A MEMBER:—We get a little quicker reaction by using the 5-per cent solution. We know the result more quickly than with the 20-per cent solution, although the 20-per cent solution has been adopted by the Bureau of Standards as the regular solution to use.

CHAIRMAN CORNELL:—Is that in an enclosed box?

A MEMBER:—Yes. It has a tilting base and a lid.

R. L. SHEPARD:—Do you figure the theoretical thickness of the nickel-plating?

MR. GRAVES:—No.

MR. SHEPARD:—My guess is that the theoretical thickness is about 0.001 in. over the whole piece on the average.

E. GRUENFELDT:—Is it not the absence of porosity in the plating which governs the length of time it will withstand the salt-spray test? Is not the thickness only valuable as a factor for diminishing the chance of porosity?

MR. GRAVES:—We believe that is partially it. Many questions on thickness have been asked, but we have never paid any attention to it.

MR. GRUENFELDT:—As nickel itself will withstand the salt spray, the thinnest film, if not porous, should be

protection against rusting. If final polishing or buffing is so important a factor for successful plating, is it not so by virtue of mechanically closing possible pores in the plate?

MR. GRAVES:—That is our theory as regards copper. Certain places cannot be plated if there are imperfections in the metal, as there always are, and we feel that the buffing of the copper fills up those places and gives something on which to plate the nickel.

CHAIRMAN CORNELL:—I am sure that, if Professor Baker were here, he would say that rust resistance is directly a function of the thickness. This is the point he emphasized last year. I am saying this on his behalf merely in partial answer to the question.

JOHN MCGEORGE:—Many years ago the Ellingtons of London made copper locomotive-boiler tubes in the days when steel was not fit for the purpose. They made those tubes by electro-depositing the metal on a mandrel with a roller going back and forth continuously over the copper deposit on the mandrel for the purpose of closing the pores.

With regard to cast ingots, a number of years ago, I put in some machinery for a large refining company that received the cast ingots direct from the furnace. We called them anodes. They averaged about 1¼ to 2½ in. in thickness. They were converted into electro-positive cathodes by the electro-depositing process and then remelted into practically pure ingots and sold. The cast anodes were never sold.

CHAIRMAN CORNELL:—Do you know the comparative purity of those two products?

MR. MCGEORGE:—I do not know. The cast anodes contained a very large percentage of impurities. They were cast near the mines.

A MEMBER:—Years ago, when we used to do bicycle work, we made what was called duplex nickel. We nickel-plated and buffed and then put on another coat of nickel. After the bicycle had been put on the roof for a year, it did not show a sign of rust on the handlebars or on the sprockets.

CHAIRMAN CORNELL:—You substituted the duplex nickel for copper.

MR. GRAVES:—I think there is no question that it would be just as good if it were put on steel, provided the pores were filled up. The reason we use copper is because it is softer and more ductile and will consequently "flow" better.

A MEMBER:—We buffed the nickel before replating it. We filled up the pores. We first used soft nickel, then put the other nickel over it and polished it in the reverse direction. We are having more rust today than we had then.

MR. SNELL:—I should like to ask Mr. Graves how he prevents nickel peeling. My understanding is that one advantage of using copper is that it prevents peeling.

CHAIRMAN CORNELL:—We are now reaching the point where we are refining what has come to be a generally accepted practice. One of the reasons for that, I believe, is that properly electroplated rustable metals, after this excellent plating process, will withstand more abrasion than will any other form of finish on any of the iron products. I wonder if Mr. Graves feels that way about it.

MR. GRAVES:—I think that is very true.

CHAIRMAN CORNELL:—That is particularly true with regard to some of the other articles of automotive usefulness, such as body hardware, which is handled and subjected to rather complicated tests of mechanical abrasion and of perspiration, which itself is something of a salt spray.

MR. GRAVES:—Our foreman remarked this morning that, when he first began to apply nickel-plating, the idea was only to get a bright luster; now, the object is to make the plating endure. So, we must do two things.

MAINTENANCE PRACTICE AT FORD PLANT

(*Concluded from p.* 85)

pany is as strict about having pipe fittings on the floor as it is about cuspidors.

Another little truck has been made a standard for the steamfitters and the millwrights. Into this truck the tool-boxes are put at night. At the present time, every millwright has a standard tool-box, equipped with tools. When he is employed, he gets a check, goes to the tool-crib, and is given the tool-box and tools, which are charged to him. Each box has a lock. In the equipment is a danger sign, to be placed on the starter of a machine on which he is working so that no one will start the machine and injure him. This sign together with two tool-boxes and the truck are shown at the left of Fig. 3.

SAVING IN BELT-CUTTING

In Fig. 8 is a little machine used in the belting cribs. At the rear are shown rolls of belting of different sizes. On the floor is a piece of steel, into which, every ½ in., is inserted a piece of brass, so that a man can go to the end of the belt that he wants, put his weight on the belt-cutter and cut the belt.

When going through a shop, you may have seen little pieces of belting, perhaps ⅛ or ¼, sometimes ⅜ in. long, if the belt man became a little reckless. When a man goes to the crib to get a piece of belting, if the man in the crib does not have a cutting machine, he uses a try-square, or marks the belt in some manner, and cuts it with his knife. As he cuts, the knife will "run" a little and will cut in. When the man begins to lace the belt, he finds that the first thing he must do is to square it. As a result, these little pieces of leather are trimmed off. About 4 months ago, I discovered this condition. I had noticed it a hundred times before but it had never impressed me. When I came to the belt machine I found a half-dozen of these little pieces on the floor.

We have a belt inspector who does nothing but watch the condition of belting. If a machine is spoiling a belt, his duty is to find out what is the matter with the machine or with the belt. I told him to select four belt-cutting machines, to pick up all the pieces of leather left on the floor in three days, and to count them. You have no idea of the money that has been thrown away during the last ten or twelve years in that factory nor of what you are wasting in your own factories.

After we had found out how many feet of belting had been thrown away in three days, we checked the requisitions for three days to see how much belting had been requisitioned. Taking an average, we found that $22.80 worth of belting was thrown away every day. The little belt-cutting machine costs about $12 or $15. I have yet to see the first piece of belting on the floor since we got that machine.

Another Aspect of Crankcase-Oil Dilution

By PAUL H. SCHWEITZER[1] *Illustrated with* CHARTS

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

ABSTRACT

WIDE differences of opinion are expressed by automobile builders regarding crankcase-oil dilution. The theories advanced in explanation of dilution fail to elucidate some important facts and must therefore be regarded as unsatisfactory. From a theoretical investigation, the author determines the conditions under which the vapors of various fuels condense during the compression stroke of the engine and, as a result of such analysis, presents the theory that "surface condensation," or the aggregation of the liquid fuel-particles on the cylinder-walls, is chiefly responsible for crankcase-oil dilution.

First, suggested explanations of the dilution are presented, references to previous experiments by several authorities are stated and these are discussed. The effect of jacket-water temperature is analyzed, and whether any condensation of fuel takes place during the compression stroke of a carbureter engine is debated.

A procedure is developed that should show the effect of compression upon a fuel-air mixture with a reasonable degree of accuracy, its details being explained and supplemented by empirical data and charts that refer to alcohol, benzene, pentane, hexane, heptane and octane, as well as by a cautionary discussion regarding the application of thermodynamic principles to the operation of the internal-combustion engine. Varied compression-conditions are treated, and the conclusion is reached that most of the fuel particles that become "condensed" are particles that never have been evaporated. Several remedies for crankcase-oil dilution are then suggested.

VIEWS regarding dilution factors that were cited by 26 automobile manufacturers and published show a remarkable diversity of opinion on this subject. Some engineers emphasize the mixture of the air temperature, some the jacket-water temperature, others the fuel volatility or the mixture-ratio and still others the piston-ring seal, as having the most pronounced effect on the rate of crankcase-oil dilution. Recent experiments have failed to give a definite solution of this problem, but they indicate that jacket-water temperature has a very marked influence on the rate of dilution.

As to the ultimate cause of the dilution, no disagreement exists. The earlier theory that the dilution is a "breaking-down" or decomposition of the oil has been discarded. It is the *liquid gasoline* that gets into the crankcase-oil and converts a viscous oil of high lubricating value into a thin oil-gasoline mixture that is inadequate to furnish a sufficiently thick oil-film to prevent excessive bearing and cylinder wear. Most of the suggested theories are based upon the assumption that the unvaporized portion of the fuel charge drains down the cylinder past the piston and dilutes the oil.

SUGGESTED EXPLANATION OF CRANKCASE-OIL DILUTION

Most dependable tests on crankcase dilution were carried out last year as a part of the fuel research by the Bureau of Standards in cooperation with the American Petroleum Institute, the National Automobile Chamber of Commerce and the Society of Automotive Engineers. The test results, as presented to the Society by Stephen M. Lee in his paper entitled Economic Motor-Fuel Volatility[2], emphasize the predominating influence of the jacket-water temperature upon the dilution. Lee gave a probable explanation[3], to the effect that the carbureter-air temperature is not high enough to vaporize all the fuel and liquid fuel is always entering the cylinder; that the least-volatile fractions are not vaporized at the time of entrance but become partly vaporized later by the hot piston and hot cylinder-walls; and then says: "The rate of dilution depends therefore upon the ability of the piston and the cylinder wall to vaporize the heaviest portion of the fuel, which is a function of the jacket-water temperature." A similar view was expressed by Dr. H. C. Dickinson[5], as follows:

> In most present-day engines, it is probable that some fuel is evaporated in the manifold, some is vaporized in the cylinder, and some—very little in most cases—fails to become vaporized in time effectively to enter into combustion. Obviously, it is this latter portion that is responsible for crankcase dilution. Apparently, the effect of an increase in the air temperature is to increase the ratio between the fuel vaporized in the manifold and that vaporized in the cylinder without appreciably decreasing the amount of fuel that is not vaporized in time effectively to enter into combustion.

Several reasons exist for regarding this explanation as unsatisfactory.

(1) According to the above theory, the piston-head temperature should have a similar influence to that of the wall temperature on the rate of dilution. The experiments carried out at the Bureau of Standards by John O. Eisinger were reported in his paper entitled Factors Affecting the Rate of Crankcase-Oil Dilution.[6] He says: "Fig. 5 shows the influence of this change in piston-head temperature to have been negligible insofar as crankcase dilution is concerned"

(2) The temperature of the mixture during the suction and the compression strokes depends greatly on, and is in fact nearly proportional to, the absolute temperature of the air at entrance to the cylinder. Hence, the ability to vaporize the heavier fractions in the cylinder will depend also upon the carbureter-air temperature. But the experiments reported by Lee show that the air temperature had no marked effect on the dilu-

[1] M.S.A.E.—Assistant professor of engineering research, Pennsylvania State College, State College, Pa.

[2] See THE JOURNAL, August, 1924, p. 117.

[3] See THE JOURNAL, July, 1923, p. 12.

[4] See THE JOURNAL, July, 1923, p. 14.

[5] See *Bulletin of the American Petroleum Institute*, Dec. 31, 1923, p. 128.

[6] See THE JOURNAL, July, 1924, p. 72.

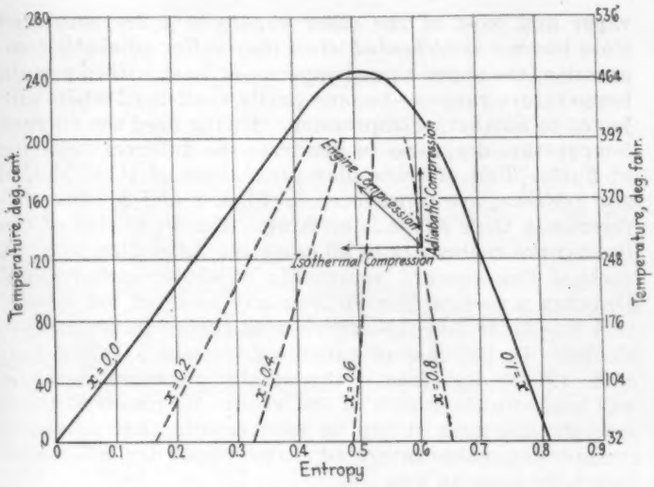


FIG. 1—ENTROPY-TEMPERATURE DIAGRAM OF ETHYL ALCOHOL
It Will Be Noticed That Wet Vapors Become Condensed when Subjected to Either Isothermal or Adiabatic Compression. On the Other Hand, Dry or Slightly Moist Vapors Become Condensed if Compressed Isothermally but Evaporate if Compressed Adiabatically, the Dividing Line Being Somewhere Between

tion. This was confirmed by the experiments of Neil MacCoull, which were reported in his paper entitled Engine Oil Consumption and Dilution.[7]

(3) Experiments by Ricardo[8] have shown that, "with a cylinder of normal design, the change in the temperature-rise of the entering gases is about one-sixth of that of the cylinder-walls." Why should the wall temperature exert a greater influence upon the vaporization of the liquid fuel entering the cylinder than the temperature of the mixture itself?

(4) The greater the unvaporized portion of the gasoline is, the less complete is the combustion and the poorer the fuel economy becomes. If the crankcase-oil dilution comes from and is about proportional to the unvaporized portion of the gasoline, then the rate of dilution should increase and decrease simultaneously with the fuel consumption per horsepower-hour. The tests referred to show no such relation. The increase of the air temperature improved the fuel consumption but did not influence the dilution, while the increase of the water temperature or of the fuel-volatility decreases considerably the dilution but has little or no effect on the fuel economy

(5) If the unvaporized portion of the gasoline is responsible for the dilution, the question arises: Why does this unvaporized portion not become vaporized during combustion? A tentative answer might be that there is not sufficient time for it. The dilution then should increase with the engine speed. The curves shown in Fig. 15 of Mr. MacCoull's paper[9] indicate the opposite effect

(6) This theory does not answer the question whether all of the unvaporized fuel dilutes the oil, or whether part goes out with the exhaust; and, in the latter case, what portion of the unvaporized fuel goes out through the exhaust-valve and what portion drains down past the piston

(7) Why does the rate of dilution slow-down when the oil becomes more and more diluted, and why does dilution sometimes cease entirely after a certain degree of dilution is attained?

[7] See THE JOURNAL, July, 1924, p. 98.

[8] See The Internal-Combustion Engine, by H. R. Ricardo, vol. 2, p. 73.

[9] See THE JOURNAL, July, 1924, p. 99.

[10] See THE JOURNAL, July, 1923, p. 3.

[11] See THE JOURNAL, July, 1924, p. 69.

EFFECT OF JACKET-WATER TEMPERATURE

Some of Lee's experiments[10] were repeated by J. O. Eisinger[11], of the Bureau of Standards, who used different engines but obtained similar results. The main factor was always the jacket-water temperature. Mr. Eisinger offered three explanations. One was similar to that of Lee, already discussed, but he discarded it after finding by experiment that the piston-head temperature had little influence on crankcase-oil dilution.

Another explanation seemed to appeal to many; namely, that the variation in the rate of crankcase-oil dilution is due to the variation in the piston-ring seal. The bulk of the liquid gasoline is prevented by the piston-rings from draining down past the piston. The rings are aided by an oil-seal in catching the fuel. As the oil gets thinner and thinner by dilution, it makes a better seal on account of its more even distribution around the piston and this explains the slowing-down of the rate of dilution. Mr. Eisinger showed, however, that this answer is wrong. In his experiments, neither the oil viscosity nor the number of piston-rings proved to have an appreciable influence on the rate of dilution. It appears that *the liquid gasoline collected on the edge of the piston cannot help but drain down,* and that no piston-ring and no oil-seal can prevent it from doing so. For example, I poured ½ pt. of gasoline on top of the pistons in various cylinders that were in good condition and had good oil-seals. The gasoline stayed in none for 3 hr., but all of it leaked down into the crankcase. When oscillating the piston slowly by hand, the drainage was more than twice as

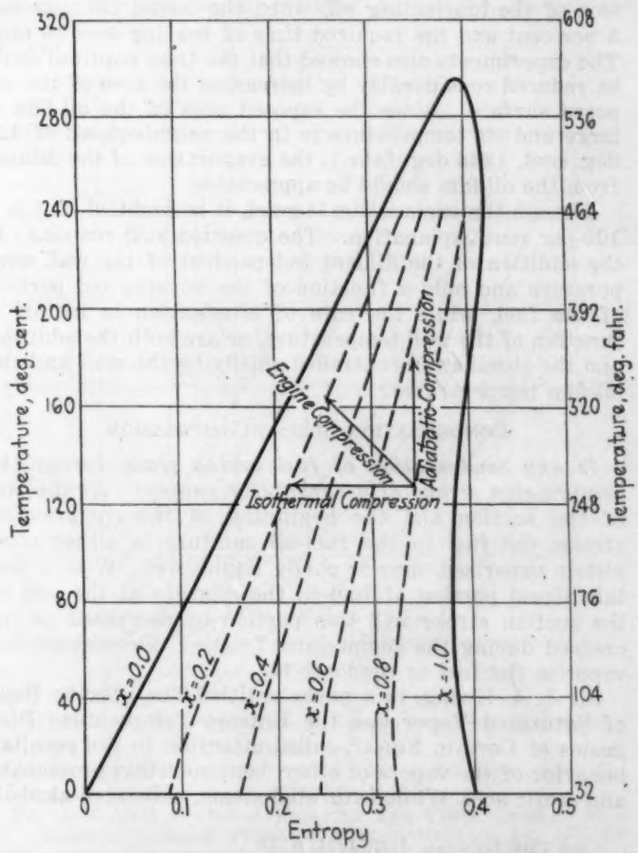


FIG. 2—ENTROPY-TEMPERATURE DIAGRAM OF BENZENE
Both Wet and Dry Vapors of Benzene Become Compressed if Subjected to Either Isothermal or Adiabatic Compression

rapid and, at engine speed, it should be very rapid indeed. If this is correct, it is futile to combat crankcase-oil dilution with perfected pistons, piston-rings and oil-seal.

A third explanation of Mr. Eisinger's is based on his experiments with artificially diluted crankcase-oil. Using a mixture of 30 per cent kerosene and 70 per cent oil, a decrease of 7 per cent in the dilution during a 5-hr. period was noted.[13] He observed also that the rate of the elimination of the diluent was greater with warm jacket-water than with cold jacket-water; so, he concluded that the influence of the jacket-water temperature on the crankcase-oil dilution is due to changes in the rate at which the diluent is *eliminated* from the oil on the cylinder-wall.

This explanation is very probable, though Mr. Eisinger[13] was reluctant to accept it on account of the fact that "the temperature of the initial-point of diluent recovered from crankcase oil ordinarily is much higher than the highest jacket-water temperature employed." But this objection has less weight if we consider that the cylinder-wall temperature is considerably higher than the water temperature; and, moreover, that the elimination will occur in the vacuum of the suction and under the reduced partial-pressure of the exhaust stroke under which the diluent evaporates at a much lower temperature than in the presence of its own vapor at atmospheric pressure. Decane, which has a boiling-point of 160 deg. cent. (320 deg. fahr.), will evaporate at 42.0 deg. cent. (107.6 deg. fahr.), if its vapor is mixed with 15 times more air into a combustible mixture. Experiments carried out at the Bureau of Standards and reported by G. A. Kramer in his paper entitled Dilution of Engine Lubricants by Fuel[14], show that a temperature of 100 deg. cent. (212 deg. fahr.) was sufficient to remove *all* the gasoline dilution of the lubricating oil, when the initial dilution was 5 per cent and the required time of heating was 16 min. The experiments also showed that the time required could be reduced considerably by increasing the area of the exposed surface. Since the exposed area of the oil-film is large and its temperature is in the neighborhood of 120 deg. cent. (248 deg. fahr.), the evaporation of the diluent from the oil-film should be appreciable.

Though the explanation is good, it is doubtful if it is a 100-per cent explanation. The question still remains: Is the addition of the diluent independent of the wall temperature and only a function of the unvaporized portion of the fuel, while the rate of elimination is mainly a function of the wall temperature, or are both the addition and the elimination controlled chiefly by the wall and the oil-film temperatures?

Condensation during Compression

Is any condensation of fuel taking place during the compression stroke of a carbureter engine? At the end of the suction and the beginning of the compression stroke, the fuel in the fuel-air mixture is either completely vaporized, dry, or partly liquid, wet. With a certain liquid portion of fuel in the mixture at the end of the suction stroke will this portion be decreased or increased during the compression? Does the compression vaporize the fuel or condense it?

Sir J. A. Ewing, in a paper entitled The Specific Heat of Saturated Vapor and the Entropy-Temperature Diagrams of Certain Fuels[15], called attention to the peculiar behavior of the vapors of ether, benzene, ethyl propionate and acetic acid. While saturated steam, saturated alcohol-vapor and most of the other vapors in a dry saturated state become *superheated* when they suffer adiabatic compression, the above-named vapors—at least within certain temperature-ranges—become partly *condensed* when subjected to adiabatic compression. Ewing used the entropy temperature-diagrams to illustrate the different behavior of fluids. Two of these diagrams, those of ethyl alcohol and benzene, are reproduced in Figs. 1 and 2. The difference in their shape is striking. The right side of the limit-curve represents in all cases the saturation line. A vertical line upward represents adiabatic compression. Drawing a vertical line up from any point of the saturation line leads into the superheated region in the case of alcohol. In the case of saturated benzene at 127.0 deg. cent. (260.6 deg. fahr.), the adiabatic-compression line will lead into the region of wet vapor. By means of these entropy diagrams it can be seen readily that adiabatic compression makes saturated alcohol-vapor dry, but makes saturated benzene wet.

It would be too hasty to draw conclusions from the foregoing characteristics of fluids in regard to their behavior in engine compression. Conditions are essentially different in the latter case; (*a*) the compression in a cylinder is not adiabatic but can be anything between isothermal and adiabatic or, at the beginning of the compression stroke, even beyond that; (*b*) the vapor at the beginning of the compression may be dry saturated, wet or superheated; (*c*) the vapor is not pure but is mixed with from 10 to 20 times its own weight of air; and (*d*) the mixture is not homogeneous, but the temperature varies considerably from the center of the cylinder to the wall.

Disregarding temporarily conditions (*c*) and (*d*), we still can use the temperature-entropy charts for the altered conditions, to predict the behavior of various fuels when compressed in an engine cylinder. If the compression is not adiabatic, the line representing the change, instead of being vertical, will be inclined, sloping to the right if the polytropic exponent of the change is greater than the adiabatic exponent, and sloping to the left if this exponent is smaller than the adiabatic exponent. The isothermal change is represented by a horizontal line in the temperature-entropy diagram. It is clear that an isothermal compression will in every case condense the saturated vapor, and that a deviation from the adiabatic in the isothermal direction has a tendency to make the vapor wetter.

Having a wet vapor instead of a dry saturated vapor to start with, the point of interest is whether the wetness will be increased or decreased by the compression. If we denote by x the vapor content and by $(1-x)$ the moisture content of 1 lb. of wet mixture, the increase or the decrease of x during the change will indicate whether evaporation or condensation has taken place. The humidities are represented in the entropy charts by lines representing different constant values of x. These lines divide the distances between the two limit curves into equal segments, as shown in Figs. 1 and 2. The effect of a certain change upon the humidity can be found by determining if the line representing the change is successively intersecting x-lines of increasing or decreasing value. Since a compression is generally connected with rising temperature, the line that represents a compression in the temperature-entropy diagram will be a rising one.

It can be seen from the diagrams that wet vapors of alcohol, and also wet and dry vapors of benzene, become condensed when they are subjected to either isothermal or adiabatic compression. On the other hand, dry or slightly moist vapors of alcohol become condensed if com-

[13] See The Journal, July, 1924, p. 72.
[13] See The Journal, July, 1924, p. 69.
[14] See The Journal, February, 1920, p. 123.
[15] See *Philosophical Magazine*, June, 1920, p. 633.

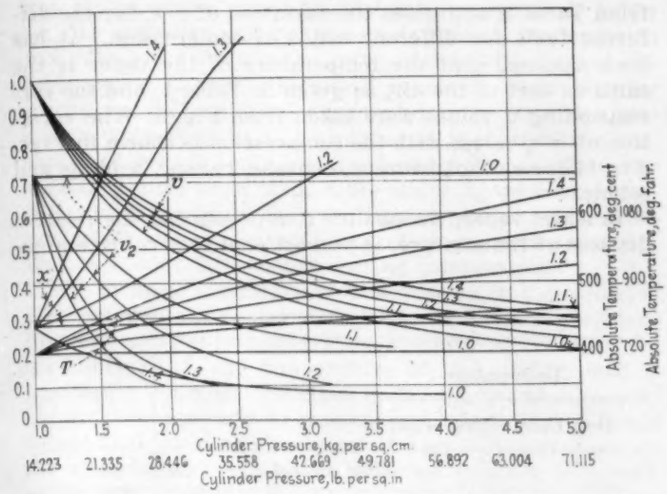

Absolute Temperature, deg. cent
Absolute Temperature, deg. fahr
Cylinder Pressure, kg. per sq. cm.
Cylinder Pressure, lb. per sq. in.

FIG. 3—CURVES OF AN AIR-STEAM MIXTURE COMPRESSED UNDER VARIOUS COOLING

The v Group of Curves Representing the Specific Volumes of the Mixture and the T Group Representing Absolute Volumes Were Plotted from Data Contained in Table 1 against Cylinder Pressures of from 1 to 5 Kg. per Sq. Cm. (14.2 to 71.0 Lb. per Sq. In.). While the Pressure of the Vapor Is Not the Same as That of the Mixture, the Temperature Is Such That the Latter Group of Curves Represent the Vapor Temperatures Also. The v_2 Group Representing the Inverse Saturation Densities of the Water Vapor Corresponding to the Temperatures Were Taken from the Steam Tables and Plotted on the Same Base for Values of n Ranging from 1.0 (Isothermal Compression) to 1.4 (Adiabatic Compression). The x Group of Curves Represents the Quality of the Steam. An Inspection of This Last Group Shows How the Quality of the Water Vapor Changes during Compression, a Drop in the Curve Indicating Condensation of the Vapor and a Rise Evaporation. For Isothermal Compression, Condensation Takes Place over the Entire Range; for $n = 1.1$, the Curve Is Almost Horizontal, Rising Slightly at the Beginning and Dropping at the End; for Adiabatic Compression Evaporation Takes Place over the Entire Range

pressed isothermally, but they evaporate if compressed adiabatically, and the dividing line is somewhere between.

We are primarily interested in liquids used as fuels in carbureter engines; such as gasoline, benzene, kerosene and alcohol. Of these, gasoline and kerosene are mixtures of various constituent hydrocarbons, and their thermodynamic properties are not uniform. Moreover, we cannot ignore the fact that these fluids never appear alone in the engine cylinder, but are mixed with various amounts of air. It is certain that the air present affects the behavior of the vapor; therefore, an investigation that does not take cognizance of the air present cannot be considered complete.

EFFECT OF COMPRESSION

From a temperature-entropy diagram of fuel-air mixtures, we can find the effect of compression upon such a mixture by the method already described. Unfortunately, no diagrams of this sort are available, and their construction is not easy. To overcome this difficulty, an alternative procedure was followed which should give the answer sought with a reasonable degree of accuracy.

If air is predominating in the mixture, as is the case with motor fuels, the highly diluted vapor behaves like a gas and Dalton's law holds within permissible limits. According to this law, each of the components fills the entire space as if the others were not present. If we have in the cylinder of V cu. ft., M_a lb. of air and M_v lb. of wet vapor of quality x, then

$$V = M_a v = M_v [x (v_2 - v_1) + v_1] \quad (1)$$

where v is the specific volume of the air, and v_1 and v_2 that of the fuel in liquid and in dry saturated states respectively. Neglecting v_1 relative to v_2, we have

$$M_a v = M_v x v_2 \quad (2)$$

and

$$x = M_a v / M_v v_2 \quad (3)$$

During compression, M_a/M_v is constant and is around 15 for gasoline. Equation (3) says that there is evaporation during compression because x increases if with increasing pressure v/v_2 increases, and there is condensation during compression because x decreases if with increasing pressure v/v_2 decreases.

The relation between v/v_2 and the pressure will depend largely upon the nature of the change. If the change is isothermal, v decreases inversely with p, the pressure, and v_2 remains constant. Consequently, the quality $x = M_a v / M_v v_2$ decreases with increasing pressure and an amount proportionate with the pressure increase becomes condensed.

An isothermal compression would cause condensation of the mixture in the cylinder with any fuel and any mixture-ratio unless the degree of the initial superheat were very high. On the other hand, if the compression is accompanied by gaining temperature, as is generally the case in the engine cylinder, the change of x cannot be so easily decided; because, while both v and v_2 will decrease with increasing pressure, the ratio v/v_2 might increase or decrease according to which of the two factors is changing more rapidly. In general, this will depend upon the nature of the change as determined by the polytropic exponent n in the equation $pv^n = a$ constant. If the exponent n is high, the compression will dry the mixture; if n is low, the compression will cause condensation and there always will be a critical exponent n_c at which the quality of the mixture remains unchanged.

CRITICAL EXPONENTIAL STUDIES

To find the critical exponent for various mixtures and conditions, I have plotted v and v_2 for air-steam, air-alcohol, air-benzene, air-pentane, air-hexane, air-heptane

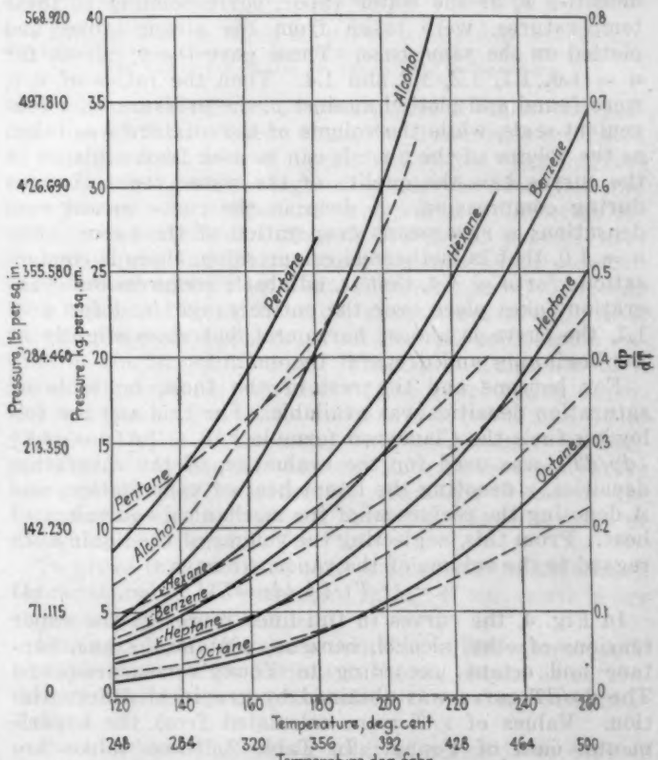


FIG. 4—CURVES OF VAPOR PRESSURE AND THEIR DERIVATIVES FOR ALCOHOL, BENZENE, PENTANE, HEXANE, HEPTANE AND OCTANE

The Vapor Pressures in Kilograms per Square Centimeter Are Plotted against Temperatures in Degrees Centigrade, the Curves Being Shown by the Full Lines. The Derivatives Were Determined by the Tangent Method and the Dotted-Line Curves Drawn

TABLE 1—VALUES OF v AND OF T, WITH n VARIABLE[16]

Pressure		v					T			
Kg. per Sq. Cm.	Lb. per Sq. In.	$n=1$	1.1	1.2	1.3	1.4	$n=1.1$	1.2	1.3	1.4
1.0	14.2	1.000	1.000	1.000	1.000	1.000	400	400	400	400
1.5	21.3	0.667	0.692	0.714	0.732	0.748	415	428	439	449
2.0	28.4	0.500	0.532	0.561	0.586	0.609	426	450	470	488
2.5	32.5	0.400	0.435	0.466	0.495	0.520	435	466	495	520
3.0	42.6	0.333	0.369	0.400	0.429	0.457	442	480	516	549
3.5	49.7	0.286	0.319	0.352	0.382	0.408	448	493	535	571
4.0	56.8	0.250	0.286	0.314	0.344	0.372	454	504	551	595

[16] Formula pv^n=a constant gives values for the specific volume and $pv=RT$ those for the temperature of the air when compressed polytropically under various amounts of cooling from the initial volume 1 and an initial temperature of 400 deg. cent. absolute, (720 deg. fahr. absolute).

and air-octane mixtures with exponents $n = 1.0$, 1.1, 1.2, 1.3 and 1.4. In the computations, the assumption always has been that the amount of vapor in the air is relatively small, so that the mixture behaves like a gas and the gas law $pv = RT$ can be applied to it. For mixtures used in automotive engines, this is permissible.

Fig. 3 shows these curves for water. From our point of view this has only theoretical interest, but it might be of practical value in studying the water emulsification of lubricating oil. The v curves and T curves for the vapor-air mixtures were obtained from Table 1 and were plotted against the cylinder pressure for 1 to 5 kg. per sq. cm. (14.2 lb. to 71.0 lb. per sq. in.) The pressure of the vapor is not the same as that of the mixture, but its temperature is the same; hence, these curves represent at the same time the vapor-temperatures. An initial temperature of 400 deg. cent. absolute (720 deg. fahr. absolute) was taken as the average temperature of the charge at the end of the suction stroke. The inverse saturation densities v_s of the water vapor, corresponding to these temperatures, were taken from the steam tables and plotted on the same base. These gave the v_s curves for $n = 1.0$, 1.1, 1.2, 1.3 and 1.4. Then the ratios of v/v_s were found and plotted against p, the pressure, to a convenient scale, while the volume of the mixture was taken as the volume of the air. It can be seen from a glance at the curves how the quality of the water vapor changes during compression. A drop in the curve means condensation; a rise means evaporation of the vapor. For $n = 1.0$, that is isothermal compression, there is condensation; for $n = 1.4$, that is, adiabatic compression, evaporation takes place over the entire range; and for $n = 1.1$, the curve is almost horizontal, but rises slightly at the beginning and drops at the end.

For benzene and the rest of the fuels, no table of saturation densities was available. For this and the following fuels the Clapeyron formula $r/T = [A(v - v_s)](dp/dT)$ was used for the evaluation of the saturation densities, r denoting the latent heat of vaporization, and A denoting the reciprocal of the mechanical equivalent of heat. From this, neglecting the volume of the liquid with regard to the volume of the vapor, we have

$$v_s = (r/T)/[A\ (dp/dT)] \qquad (4)$$

In Fig. 4, the curves in full lines represent the vapor tensions of ethyl alcohol, benzene, pentane, hexane, heptane and octane, according to Young's measurements. The dp/dT curve was obtained by graphical differentiation. Values of r/T were calculated from the experimental data of Young. In Table 2, these values are listed for the fuels just noted; in the last column, the specific volumes of the saturated vapors were calculated from Equation (4). The variations of v_s are represented in Fig. 4.

Table 3 was computed from the curves of Fig. 5 and from Table 1, and gives the variation of v/v_s for the different fuels for different ratios of compression. It has been assumed that the temperature of the vapor is the same as that of the air, as given in Table 1, and the corresponding v_s values were taken from Fig. 5. The variation of v/v_s values with the compression is shown in Figs. 6 to 11 for alcohol, benzene, pentane, hexane, heptane and octane.

In a wet vapor, the quality x, representing the relative dryness of the mixture, is proportional to v/v_s. Examina-

TABLE 2—CALCULATED VALUES OF n/T

Temperature		dp/dT	n/T	V_s[17]
Deg. Cent.	Deg. Fahr.			
Ethyl Alcohol				
120	248	0.130	0.469	0.1540
140	284	0.200	0.414	0.0857
160	320	0.320	0.362	0.0483
180	356	0.420	0.307	0.0314
200	392	0.540	0.246	0.0195
Benzene				
120	248	0.070	0.220	0.1340
140	284	0.100	0.200	0.0854
160	320	0.140	0.182	0.0553
180	356	0.182	0.164	0.0385
200	392	0.235	0.145	0.0263
220	428	0.285	0.126	0.0189
240	464	0.360	0.105	0.0125
Normal Pentane				
120	248	0.208	0.1640	0.0335
140	284	0.256	0.1385	0.0231
160	320	0.330	0.1115	0.0144
180	356	0.398	0.0773	0.0085
Normal Hexane				
120	248	0.096	0.1770	0.0790
140	284	0.130	0.1540	0.0503
160	320	0.173	0.1330	0.0328
180	356	0.224	0.1125	0.0215
200	392	0.284	0.0900	0.0135
220	428	0.355	0.0616	0.0074
Normal Heptane				
120	248	0.047	0.180	0.1635
140	284	0.068	0.162	0.1016
160	320	0.092	0.144	0.0670
180	356	0.124	0.128	0.0440
200	392	0.165	0.112	0.0290
220	428	0.218	0.095	0.0186
240	464	0.284	0.074	0.0113
260	500	0.364	0.044	0.0052
Normal Octane				
120	248	0.028	0.1815	0.2780
140	284	0.040	0.1645	0.1255
160	320	0.050	0.1500	0.1144
180	356	0.078	0.1345	0.0736
200	392	0.105	0.1210	0.0494
220	428	0.139	0.1055	0.0324
240	464	0.180	0.0900	0.0213
260	500	0.223	0.0723	0.0138

[17] The specific volumes of the saturated vapors of various fuels by the formula $v_s = 427[(n/T)/(dp/dT)]$.

tion of the curves shows that, if the exponent n is below 1.1, the humidity will be increased; that is, condensation will take place during the compression with any of the fuels except alcohol, which will evaporate under similar conditions. The critical exponent for the liquids examined is very close to 1.1; probably it is highest for benzene and lowest for alcohol. Among the paraffins, the heavier grades seem to be more stable against condensation and evaporation than the lighter grades. Above the critical exponent, the humidity of the vapors decreases, that is, evaporation occurs, during compression.

The average exponent for compression in a well-cooled internal-combustion engine is 1.3, which makes it evident that evaporation is taking place during compression. On the other hand, the temperature of the cylinder-wall is practically constant during a cycle; so, the change near the cylinder-wall is nearly isothermic. From this it would follow that some condensation of fuel will take place on the cylinder-wall unless the entering mixture is considerably superheated.

Application of Thermodynamic Principles

Great caution is necessary in applying the principles of thermodynamics to the operation of the internal-combustion engine. We know generally that a vapor can possess one of three stages; it can be either wet, saturated or superheated. It is a discomfort to find that the fuel vapor in the gasoline-engine cylinder is both wet *and* superheated. It is true that a vapor in equilibrium remains wet saturated so long as it stays in contact with its own liquid, and that no vapor becomes superheated in the presence of its liquid. Equilibrium, however, means that vapor and liquid have the same temperature. As a rule, the wet fuel-charge of an internal-combustion engine is not in equilibrium. The liquid drops are at a lower temperature than that of the surrounding vapor. So, it might happen that a vapor is wet, containing liquid globules, and is at the same time superheated, its temperature being higher than the saturation temperature corresponding to its pressure. And this is exactly the case during the suction and the compression strokes of the automobile engine.

To prove this, we have only to calculate the saturation temperatures of the respective fuels. If the vapor is dry saturated, $x = M_a v / M_v v_s = 1$.

Setting for M_a/M_v the proportion of the proper combustible mixture for various fuels, we obtain as saturation temperatures approximately the values shown in Table 4.

Even decane, the boiling-point of which is as high as 160 deg. cent. (320 deg. fahr.) and which forms one of the heavy-end components of gasoline, has a saturation temperature of 46.0 deg. cent. (114.8 deg. fahr.), if mixed with 12.7 times its own weight of air into a perfect combustible mixture. The suction temperature is consider-

[19] See The Internal-Combustion Engine, by H. R. Ricardo, vol. 2, p. 53.

TABLE 3—VARIATION OF v/v_s FOR THE DIFFERENT FUELS AT DIFFERENT RATES OF COMPRESSION[18]

Pressure		Alcohol	Benzene	Pentane	Hexane	Heptane	Octane
Kg. per Sq. Cm.	Lb. per Sq. In.						
			$n=1.0$				
1.0	14.2	7.88	8.74	33.90	14.70	7.20	4.22
1.5	21.3	5.25	5.82	22.60	9.76	4.80	2.82
2.0	28.4	3.93	4.32	17.00	7.35	3.60	2.11
2.5	32.5	3.15	3.50	13.50	5.88	2.88	1.69
3.0	42.6	2.62	2.92	11.50	4.90	2.40	1.41
3.5	49.7	2.25	2.50	9.55	4.20	2.06	1.20
4.0	56.8	1.97	2.18	8.50	3.68	1.80	1.06
			$n=1.1$				
1.0	14.2	7.88	8.74	33.90	14.70	7.20	4.22
1.5	21.3	8.76	8.54	32.20	14.40	7.13	4.15
2.0	28.4	9.25	8.31	31.30	14.15	6.91	4.00
2.5	32.5	9.46	8.18	31.00	14.00	6.80	3.95
3.0	42.6	9.36	7.94	31.50	13.90	6.71	3.92
3.5	49.7	9.22	7.78	.....	13.70	6.51	3.89
4.0	56.8	9.40	7.62	.....	13.95	6.65	3.97
			$n=1.2$				
1.0	14.2	7.88	8.74	33.9	14.70	7.20	4.22
1.5	21.3	13.20	11.70	44.0	19.80	9.65	6.10
2.0	28.4	16.90	14.00	59.0	25.00	11.90	7.15
2.5	32.5	20.10	15.50	.....	.....	13.80	8.33
3.0	42.6	24.70	17.00	.....	.....	16.00	9.51
3.5	49.7	.....	19.00	.....	.....	18.90	10.08
4.0	56.8	.....	20.90	.....	.....	.....	12.05
			$n=1.3$				
1.0	14.2	7.88	8.74	33.9	14.70	7.20	4.22
1.5	21.3	17.40	14.80	57.6	25.65	12.40	7.32
2.0	28.4	27.60	20.90	.....	.....	18.90	11.35
2.5	32.5	.....	27.50	.....	.....	27.50	16.40
3.0	42.6	.....	35.70	.....	.....	38.20	21.40
3.5	49.7	.....	.....	.....	.....	.....	29.40
4.0	56.8	.....	.....	.....	.....	.....	.....
			$n=1.4$				
1.0	14.2	7.88	8.74	33.9	14.7	7.20	4.22
1.5	21.3	22.00	18.25	77.0	34.0	15.55	9.45
2.0	28.4	48.70	30.80	.....	.....	29.00	16.90
2.5	32.5	.....	.....	.....	.....	58.00	28.10
3.0	42.6	.....	.....	.....	.....	.....	.....
3.5	49.7	.....	.....	.....	.....	.....	.....
4.0	56.8	.....	.....	.....	.....	.....	.....

[18] From Equation (3), $x = M_a v / M_v v_s = 1$, the increase or decrease of v/v_s indicates the decrease or the increase of the humidity of the wet vapor. In this table, $v/v_s = 1$.

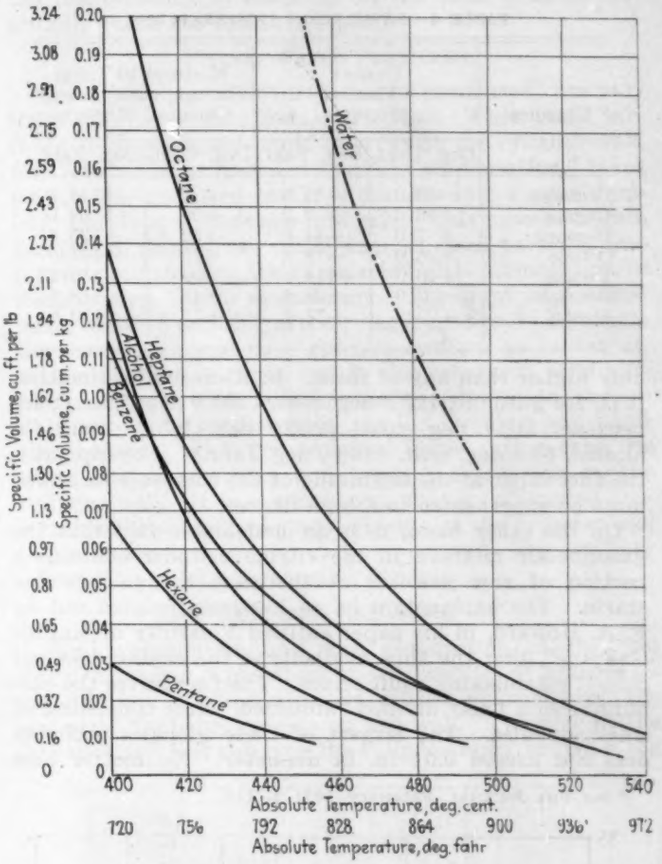


FIG. 5—CALCULATED SPECIFIC VOLUMES OF SATURATED VAPORS OF DIFFERENT HYDROCARBONS

The Hydrocarbons for Which the Curves Were Plotted Are Alcohol, Benzene, Pentane, Hexane, Heptane and Octane. The Corresponding Curve for Water Is Added for Comparison

TABLE 4—SATURATION TEMPERATURES

Chemical	Correct Chemical Mixtures		Mixtures 10 Times Stronger than Correct Chemical Mixtures	
	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Pentane	—35.0	—31.0	+ 5	+ 41.0
Hexane	—16.0	+ 3.2	+20	+ 68.0
Heptane	+ 7.0	+44.6	+52	+125.6
Octane	+26.0	+78.8	+75	+167.0
Decane	+46.0	+114.8	+99	+210.2
Benzene	— 2.0	+28.4	+48	+118.4
Alcohol	+25.2	+77.4	+77	+170.6

ably higher than any of these. In Ricardo's[29] estimation, it is, for gasoline, 125.5 deg. cent. (258.0 deg. fahr.); for benzene, 112.7 deg. cent. (235.0 deg. fahr.); and for alcohol, 65.6 deg. cent. (150.0 deg. fahr.). Consequently, the fuel vapor at the beginning of the compression stroke must be superheated to a high degree.

On the other hand, it is an undeniable fact that the gasoline-air mixture in the engine cylinder contains a portion of raw gasoline at the time the compression starts. The explanation is, as has been pointed out by F. A. Howard, in his paper entitled Volatility of Engine Gasoline[29], that the time available in the engine does not permit establishing equilibrium. The fuel leaves the carbureter in a finely divided "atomized" state consisting of small globules. The largest of these globules probably does not exceed 0.01 in. in diameter. No matter how

[29] See THE JOURNAL, February, 1921, p. 145.

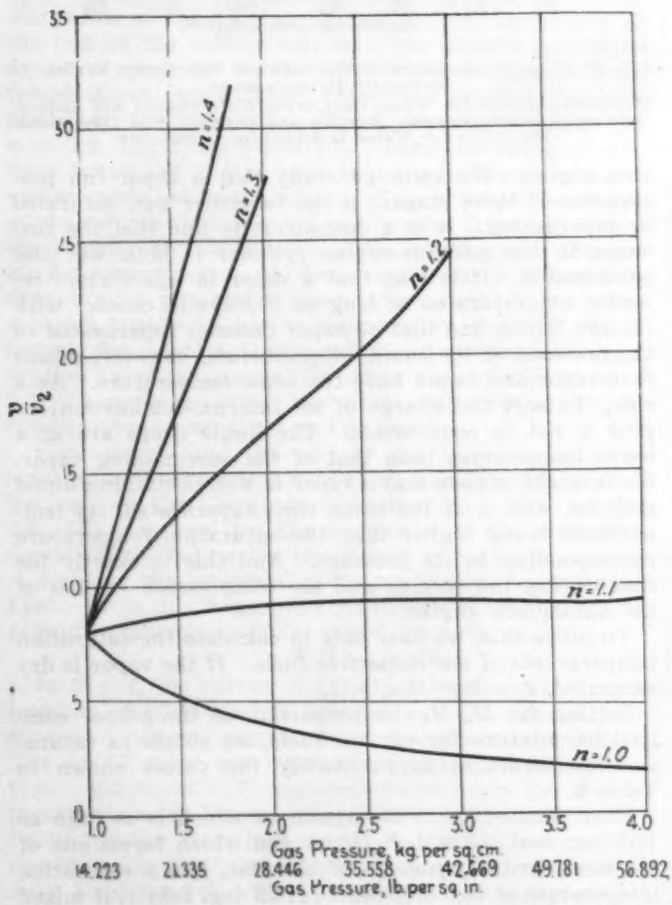


FIG. 6—VARIATION IN THE HUMIDITY OF A MIXTURE OF AIR AND ALCOHOL VAPOR

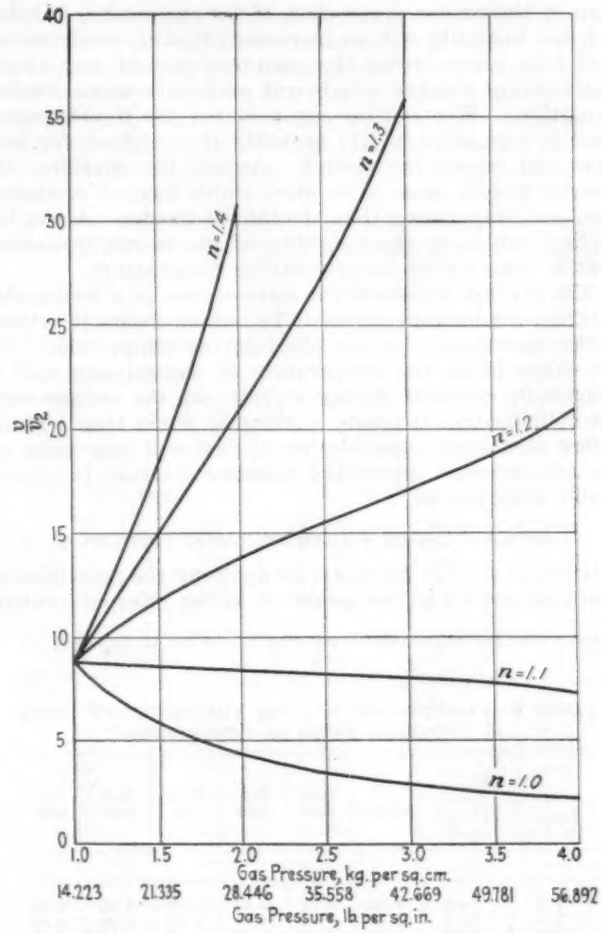


FIG. 7—VARIATION IN THE HUMIDITY OF A MIXTURE OF AIR AND BENZENE VAPOR

small the globules are, it takes a certain time to transfer heat from the surrounding air into the body of the liquid drop. Moreover, the globules are at the same time cooled by the evaporation taking place on their surface. So, when entering the cylinder, one part of the charge is still in a liquid state and even the heat of the residual gases is not sufficient to supply the heat fast enough to bring all the liquid above the saturation temperature; also, a certain amount of liquid particles of lower temperature than that of the vapor will be present when compression starts.

COMPRESSION CONDITIONS

What we have in the beginning and during compression is neither a wet vapor nor a superheated vapor, but a mixture of superheated vapor with atomized liquid. The liquid particles are suspended in the vapor-air mixture, and form a cloud in it. The fuel that has been vaporized is so much superheated that it cannot become condensed even if subjected to an isothermal compression, because its dew-point temperature is considerably lower than the temperature of either the gas or the cylinder-wall. It might have a tendency to condense without ever actually reaching the saturation-point.

Conditions are different when starting a cold engine. With cold jacket-water and cylinder-wall and in the absence of the hot residual gases, the suction temperature will be as low as or lower than the outside air temperature, say 15 deg. cent. (59 deg. fahr.). At the same time, by the use of the choke, the mixture strength will be in-

creased to be from 6 to 12 times that of the chemically correct mixture. Under these conditions, the corresponding saturation temperatures of the gasoline constituents approximately will be those that are given in the second column of Table 4.

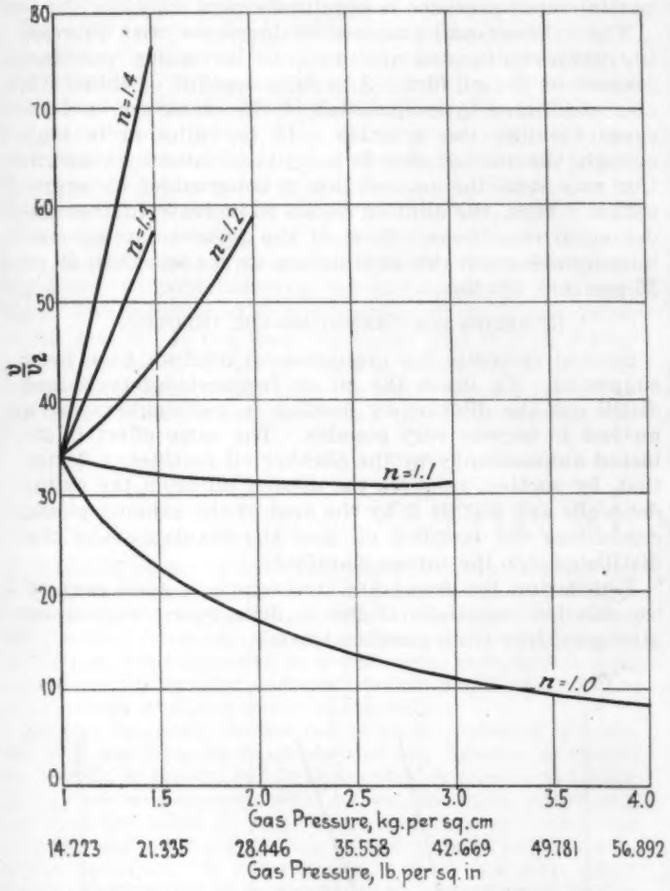


FIG. 8—VARIATION IN THE HUMIDITY OF A MIXTURE OF AIR AND PENTANE VAPOR

It will be noted that, *at starting*, most of the gasoline constituents have a saturation-point above the suction temperature and above the wall temperature. Consequently, one part of the charge will be wet saturated and one part slightly superheated. A near isothermic compression that takes place near the wall will condense this vapor as the curves in Figs. 7 to 11 indicate.

In a warm engine, during the suction and in the beginning of the compression stroke, the gas mixture is absorbing heat from the cylinder-wall. The layers near the wall are warmer than the inner layers and their rate of evaporation is higher. Some of the later vaporized particles will not have time to become highly superheated, but will be around the saturation stage during the early compression period. When a near-isothermic compression is applied, the effect will be a re-condensation of these particles. At the time this happens, on account of the advance of the piston, the temperature distribution has already changed. The gas has been heated-up by the compression, and the wall and the adjacent layers are cooler than the rest of the charge. A slight wall-condensation is possible even with a completely dry mixture.

On the other hand, in a normal running engine, the average suction temperature will be around 125 deg. cent. (257 deg. fahr.), as mentioned, and the wall temperature probably will be somewhat higher. The gasoline vapor at this temperature is so much superheated that, even if it has the tendency to condense on the wall, it never can actually reach the saturation-point.

UNEVAPORATED PARTICLES

Most of the particles that become "condensed" are particles that never have been evaporated. When these particles of the atomized liquid impinge on the cylinder-wall, film formation, or so-called "surface condensation," takes place. The atomized particles coalesce into bigger droplets; the cloud transforms into rain. This process of rain formation, that is, the coalescence of small particles into bigger droplets, has the same relation to atomization as condensation has to evaporation. For want of a better term, we shall call this process "aggregation." Aggregation can take place in a gaseous medium as in the atmosphere when it rains, but it also occurs on solid surfaces. This is often called surface condensation, though it is not really condensation at all. Nothing but vapor can condense. It is the atomized liquid rather than the vapor that precipitates and forms a liquid film on the cylinder-wall. It is a well-known fact in oil-engine construction that the fuel-spray which hits the cylinder-wall is practically lost for combustion purposes. The capillary adhesion is chiefly responsible for this.

DILUTION EXPLAINED

Wall aggregation and wall evaporation of the fuel furnish a clear explanation of the problem of crankcase-oil dilution. The dilution is caused primarily by the atomized fuel that collects on the wall. The rest of the unvaporized fuel entering the cylinder remains like a fog

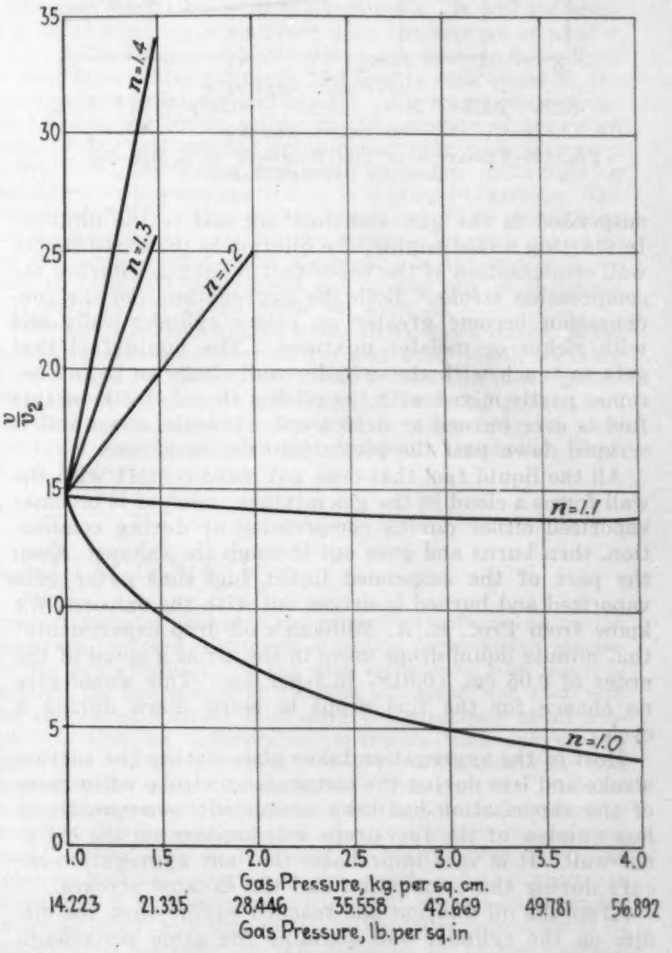


FIG. 9—VARIATION IN THE HUMIDITY OF A MIXTURE OF AIR AND HEXANE VAPOR

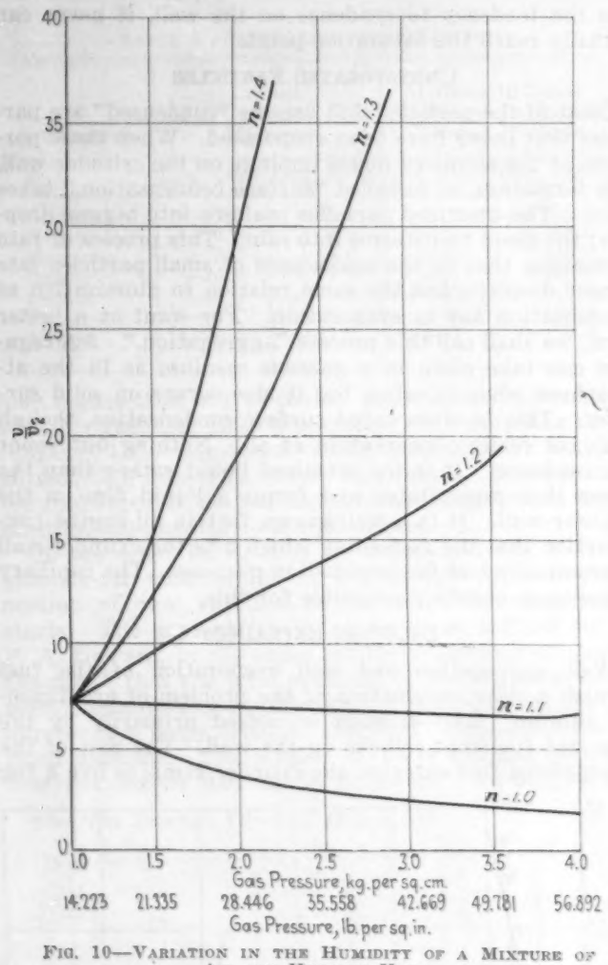


FIG. 10—VARIATION IN THE HUMIDITY OF A MIXTURE OF AIR AND HEPTANE VAPOR

suspended in the gas, and does not add to the dilution. In starting a cold engine, the dilution is increased by the wall condensation of the vapor that takes place during the compression stroke. Both the aggregation and the condensation become greater on colder cylinder-walls and with richer or moister mixtures. The liquid fuel that gets in touch with the cylinder-wall clings to it and becomes partly mixed with the oil-film there. Little of this fuel is ever burned or driven out. It leaks down and is scraped down past the piston into the crankcase.

All the liquid fuel that does not make contact with the wall forms a cloud in the gas mixture; most of it becomes vaporized either during compression or during combustion, then burns and goes out through the exhaust. Even the part of the suspended liquid fuel that never gets vaporized and burned is driven out with the exhaust. We know from Prof. R. A. Millikan's oil-drop experiments[21] that minute liquid drops move in the air at a speed of the order of 0.05 cm. (0.0197 in.) per sec. This would give no chance for the fuel drops to settle down during a cycle.

Most of the aggregation takes place during the suction stroke and less during the compression stroke when more of the vaporization has been completed; consequently, a less number of the fuel drops will impinge on the cylinder-wall. It is very improbable that any aggregation occurs during the combustion and the exhaust strokes.

After the oil dilution has reached equilibrium, the oil-film on the cylinder-wall contains the same percentage amount of diluent as does the crankcase-oil. This mixture of oil and diluent fuel is exposed to the heat of the cylinder-wall and of the adjacent gas; consequently, the more volatile diluent will evaporate. Most of the evaporation will occur during the exhaust stroke when the partial vapor-pressure is practically zero.

The cylinder-wall evaporation increases with increasing temperature, and also with an increasing gasoline-content of the oil-film. A certain amount of diluent is also eliminated by evaporation in the crankcase, and escapes through the breather. If the dilution is high enough, the amount that is being eliminated by evaporation may equal the amount that is being added by aggregation. Then, the dilution ceases to increase further under equal conditions. Most of the present-day automobile-engines reach this equilibrium at not less than 20 or 25-per cent dilution.

REMEDIES FOR CRANKCASE-OIL DILUTION

Several remedies for crankcase-oil dilution have been suggested. To drain the oil at frequent intervals and distill out the dilution by heating is too cumbersome a method to become very popular. The same effect is attained automatically by the Skinner oil rectifier, a device that, by suction, removes the diluted oil from the cylinder-walls and distills it by the heat of the exhaust gases, conducting the rectified oil into the crankcase and the distillates into the intake-manifold.

Ventilating the crankcase counteracts a good part of the dilution, especially if this is done by circulating an airstream free from gasoline vapor.

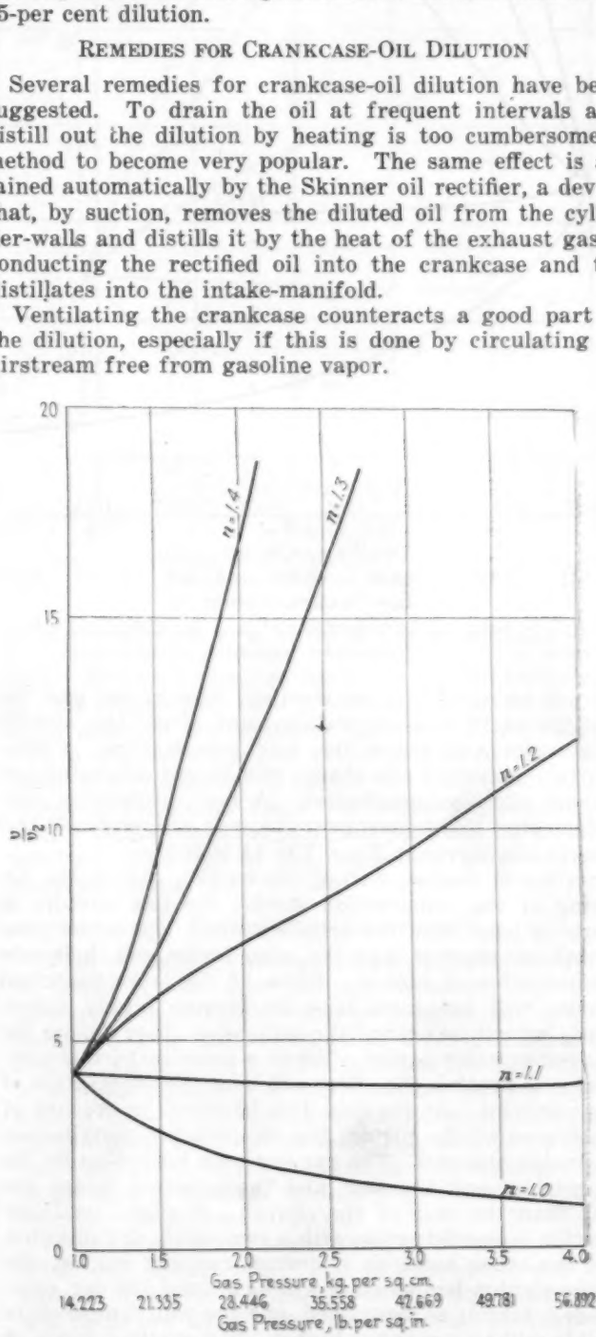


FIG. 11—VARIATION IN THE HUMIDITY OF A MIXTURE OF AIR AND OCTANE VAPOR

[21] See The Electron, by R. A. Millikan, p. 90.

Anything that produces more complete vaporization reduces the number of liquid particles that strike the cylinder-wall. Finer atomization and hot-spot manifolds have this effect. If the impinging globules are small, the cylinder-wall will be able to vaporize more of them and less will coalesce and drain down.

Keeping the jacket-water warm is undoubtedly one of the most effective ways to reduce crankcase-oil dilution. A thermostat in the water circulation and a radiator shutter are helpful. Most of the dilution occurs during the warming-up period when starting the engine. This warming-up period should be shortened. Small jacket spaces and a thermostat in the line are advantageous in this respect. To raise the temperature of the cylinder-wall where the condensation and the evaporation of the diluent take place, the jacket space should be shorter and narrowing down, without reducing the cooling of the cylinder-head. The water inlet is now usually at the lowest point of the jacket. It has been suggested that this be placed close to the head. Since the natural convection is upward, this arrangement would keep the water around the cylinder at a higher temperature than the water around the head. The oil temperature should be kept more uniform. The warming-up of the crankcase-oil takes several hours with the present-day engines. A lubrication system and automatic devices that make the lubricant warm-up quickly and keep its temperature uniform would be desirable. Probably an adjustable cover on the oil panel would do some good.

By these and some other means, the wall condensation can be reduced and the wall evaporation can be increased to a point where the dilution in the engine would reach equilibrium with not more than from 5 to 10-per cent dilution, and the dilution never would exceed this equilibrium under normal conditions. Such slight dilution is not harmful to the lubrication, provided the oil is of the proper viscosity and clean. One solution of the dilution problem would be to run the engines with diluted oil, designing them so that the dilution equilibrium would be reached at a low percentage, keeping the oil clean through use of filters and air-cleaners, and maintaining its temperature uniform. Then, we should be able to run the engine many times longer without draining the crankcase.

THE NEXT WAR

I WOULD prefer to have the people who would avoid the next war entertain the will to peace because of a carefully-wrought understanding of what the next war will mean. Within the limitations that I have set on our indulging in prediction, some speculation would seem permissible, built upon observations of human methods and human motives that remain more or less constant in experience.

On this reasoning we are not so much concerned whether the next war is to be fought around the Atlantic or around the Pacific, in Europe, in South America, in Asia or in Africa. Rather are we concerned with the ways in which people will approach the brink of reason, the leap they will take over its edge, and the struggle they will go through to pull themselves up again. In other words, I think we may safely direct our attention to an inquiry as to how the cards will be stacked before we go into the next war, how they will be shuffled while we are in it, and how we may expect them to be dealt out again after the war is over.

On the assumption that by "world war" we mean a conflict involving so many states that it would deserve that name, how is it likely to come about, by what method will it be conducted, and what will determine its probable issue?

For a decade prior to the last war we were constantly being warned of danger. From Algeciras to Agadir, a whole procession of events now seems to have announced the conflict. But there was no continuous discussion on which public interest centered; there was no organization in the world for cooperative deliberation; there was no forum in which searchlights could be turned on the forces that were active.

The next war is by no means inevitable. It will not come in spite of what the human race does, but because of what it does. If the League of Nations does not prevent it, we shall at least have better warnings and clearer indications of the issues involved than we had in 1914. We may have a struggle between one group acting on the mandate of organized world-society and another group challenging such authority. In this event, the former group will be as free in its fighting the outlaw as a policeman is free in making his arrests. The law of neutrality will go by the board and whole populations will be combatants. During the struggle we may expect to see the cards shuffled many times, and at the end of it we shall be fortunate if we come out holding any of the cards that were in our hands when we went in.

"The earth belongs always to the living generation." What does our generation will about the next war? Shall we bring it on, or shall we stave it off? Shall we hand on to the generation that will follow us a heritage of menacing policies and brooding hates, or shall we hand on to it a heritage of well-organized cooperation and ever increasing goodwill?—Prof. M. O. Hudson.

AVIATION INSURANCE

THE *Insurance Record*, of London, remarks that the safe conclusion of the record-breaking flight of the German-built airship, ZR3, now the Los Angeles, to the United States, is naturally of interest to underwriters. It is said the dirigible was insured for a total of about £120,000 (approximately $550,000). It is understood that the greater portion of the insurance on the airship was borne by what is known as the British Aviation Insurance Group. This represents a consolidation, for aviation insurance purposes, of several important British insurance companies and a large number of Lloyd's underwriters. Some hundreds of underwriters participate in the scheme; so, altogether, the security offered is very considerable indeed.

Both the managements of the insurance companies and the individual underwriters have felt that they should provide the insurance necessary for the development of the aviation industry and that the proper way of conducting the insurance business is through a central organization concentrating solely upon it. In the past, losses have been incurred through the transaction of aviation insurance, and even now the volume of business is of such comparatively small proportions that an unfavorable experience with one or two important risks could hardly fail to affect adversely the results of the central organization. However, the interests in the scheme are so numerous that the actual loss affecting each underwriter would be minute. Not only is the existing machinery valuable as providing by far the most important aviation insurance market in the world—aviation risks are brought to it from many countries—but it could be expanded easily to practically any extent to meet the requirements of the aviation industry as this develops in future years.—*Economic World.*

Power and Gasoline Economy of the Present-Day Passenger-Automobile

By A. A. Straub[1]

Illustrated with Photographs and Drawings

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

DATA obtained from road-tests made with a modern six-cylinder phaeton are analyzed by the author in an effort to substantiate his belief that the full capabilities of an automobile will be realized if the builder's instructions regarding the maintenance and the adjustment of the engine and its accessories are adhered to rigidly.

After carrying out the builder's instructions in every particular to get the car into prime condition, a 1700-mile trip that included both touring and city driving resulted in the attainment of an average fuel-consumption of 18.35 miles per gal. A subsequent 1000-mile trip over level improved roads, made under identical conditions except that the car had received preliminary adjustment at a service-station, resulted in a fuel consumption of 15.4 miles per gal. On the 1700-mile trip, the hill-climbing ability was excellent. On the 1000-mile trip, hill-climbing ability was fair only, and scarcely 75 per cent of the power capacity was realized. Other unfavorable features of the 1000-mile trip were that the engine backfired rather frequently unless the choke was used slightly, resulting in a tendency toward oil-pumping and fouled spark-plugs, and carbon removal was necessary after the test.

Making an analysis of the graphic results, the author says that they show the carbon-dioxide content of the exhaust gas, the air-fuel ratio and the completeness-of-combustion curves to be identical in character, and that hence the carbon-dioxide content is a direct index of the efficiency of carbureter adjustment. The negligible effect of low-speed-nozzle adjustment and the marked effect of high-speed-nozzle adjustment at a car speed of 15 m.p.h. are shown by the curves, and this corroborates the builder's statement that the effect of the low-speed-nozzle adjustment is relatively negligible at speeds exceeding 8 m.p.h.

Numerous details of the performance are presented and discussed. Major conclusions reached include a plea that manufacturers instruct service-station attendants in the principles of combustion and of the value of exhaust-gas analysis for the determination of the efficiency of carbureter adjustment, and that they time engines according to instructions. The results presented prove that an intelligent application of basic principles produced a 30-per cent gasoline-mileage increase, with increased power and flexibility attained at a lower maintenance cost and with less inconvenience. The desirability of using such means for conserving the Nation's gasoline supply is stated, and its financial advantage is calculated.

ALTHOUGH the present-day automobile embodies the highest development of various branches of modern engineering science, the gasoline mileage and the power capabilities of the machine are seldom realized and are still less frequently obtained when it is in the hands of the average driver. The service-station attendant or mechanic is often responsible for this, although well meaning, due to a lack of appreciation of the refined and intensively developed features involved. That this condition exists is proved by the fact that often, when adjusted and attended at a service-station, machines give unsatisfactory performance and poor gasoline-mileage; but, in the hands of the same driver, they will give highly satisfactory performance and develop maximum power with high gasoline-mileage when adjusted with care and with respect to the underlying principles. Respect of basic principles in maintenance will result in creating a driving public that will be better satisfied, and cause a great saving in the Nation's gasoline supply.

The principal causes of poor performance are maladjusted timing and carbureters; and the main contributing factors are negligently and improperly adjusted valves, throttle and spark-plugs.

It is a well recognized fact that, coincident with the proper adjustment of the carbureter, the valves should be ground and adjusted properly. Spark-plugs should be clean, having the points set to the proper size of gap, and all connections should be bright and free from grease. The throttle valve should be adjusted properly and, most important, the engine should be timed correctly. It is difficult to understand why the instructions of the manufacturer for timing engines should be ignored so completely by service-station attendants, and why engines generally are timed by the guess method. My own experience is that service-station timing by guess results in unsatisfactory performance, poor gasoline-mileage, backfiring and the use of too-rich mixtures. When I timed the same car in strict accordance with the manufacturer's instructions, this resulted in ability to use leaner mixtures, the attainment of increased power and flexibility and an increase in gasoline mileage. It has been found also that intelligent use of the choke practically will eliminate starting difficulties on a cold engine, even with lean mixtures, if the engine is timed properly and the spark-plugs are clean and adjusted properly. My experience is that, if the manufacturer's instructions are followed rigidly in maintenance and in adjustment, and all parts are kept scrupulously clean, highly satisfactory performance will be obtained.

In the following discussion, the results attendant on both methods of adjustment are given, as well as the results of studies made of the carbureter operating-characteristics at different settings of the needle-valve.

Type of Car and Fuel Used

A Studebaker 1922 Model E.J.-6 phaeton was driven and used for testing. It has a six-cylinder engine of 3⅛-in. bore and 4½-in. stroke, rated at 23.45 hp. It is of L-head type, with inclined valves and spark-plugs in the head, over the edge of the pistons. The rear-axle gear-ratio was 4.55 to 1. Pneumatic 32 x 4-in. tires were used. A Studebaker model Stromberg O.S.-1 car-

[1] Mechanical engineer, Pittsburgh.

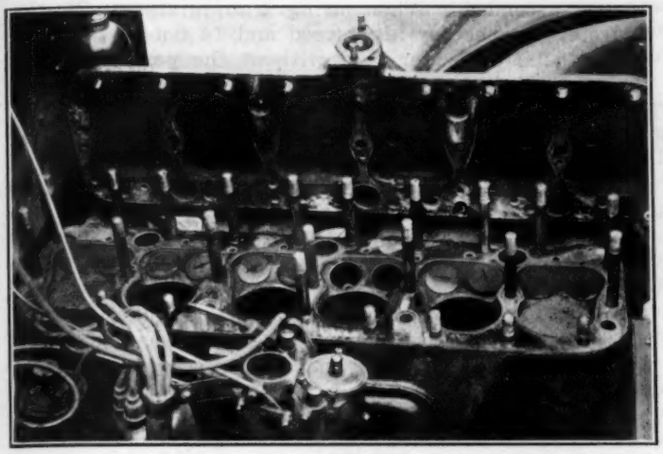


FIG. 1—NATURE AND EXTENT OF CARBON DEPOSIT AFTER 2000 MILES OF DRIVING USING A LEAN MIXTURE
The Carbon in the Valve-Chambers Was in the Nature of a Soot and Was Probably from 0.005 to 0.007 In. Thick. That on the Cylinder-Heads and the Pistons Had a Shiny Vitreous Appearance and Probably Was a Lubricating-Oil Carbon. The Thickness Averaged That of an Egg-Shell and the Carbon Flaked Off in Pieces Approximately ¼ In. Square on Scraping

bureter, having one high-speed and one low-speed jet was bolted directly to the removable engine-head, which also contained the intake-manifold.

The grade of gasoline used was that marketed in the Pittsburgh district as motor or automobile gasoline of average analysis, as shown in Table 1. This gasoline requires 15.1 lb. of air per lb. of gasoline to give chemically perfect combustion.

TABLE 1—QUALITIES OF THE GASOLINE FUEL USED

Specific Gravity at 60 deg. fahr.	0.739
Specific Gravity, American Petroleum Institute Scale, deg.	60
Distillation	Deg. Fahr.
First Drop	109
Percentage Distilled 20	203
Percentage Distilled 50	271
Percentage Distilled 90	374
Dry-Point	428
Average	271
Recovery and Ultimate Analysis	Per Cent
Recovery	96.0
Residue	1.0
Loss	3.0
Carbon	84.5
Hydrogen	15.5

ENGINE ADJUSTMENT

Preparatory to driving this car over the mountains of Pennsylvania and northern Maryland, the carbon was scraped from the engine, the valves were ground carefully and finally were adjusted while the engine was warm, after they had worn-in. The spark-plugs were cleaned and set to have 0.025-in. gaps, using a feeler gage. The engine was timed according to manufacturer's instructions which, upon checking against No. 1 cylinder on dead-center and compression with the spark-lever retarded, showed the breaker-points just breaking for No. 1 terminal. The throttle was adjusted to give a smooth slow-idling engine with a proper carbureter-setting. The carbureter was adjusted to have its high-speed jet 26 notches from the closed position and its low-speed jet 14 notches from open position; adjustments were made from data on hill-climbing-ability tests conducted by a local representative. Intake air to the carbureter was supplied according to the manufacturer's instructions for summer driving.

ROAD PERFORMANCE

With the car in prime condition, adjusted as described and when carrying two passengers and baggage, it was possible to ascend all mountains traversed by the National and the Lincoln Highways between New York City and Pittsburgh, in high gear without excessive engine heating, during the month of August. I was informed and noted that cars of similar power and type having wheels of smaller diameter were encountering difficulties on the same highways, trouble that probably was due to poor adjustment. An average gasoline-mileage of 18.35 miles per gal. was obtained on a 1700-mile trip, including touring and city driving.

CARBURETER ADJUSTMENT FOR MILEAGE

Judging from the performance on this trip, it was thought a leaner adjustment of the carbureter would suffice for power requirements in the vicinity of Pittsburgh, and that better gasoline-mileage would be obtained. The carbureter was adjusted two notches leaner on both high-speed and low-speed nozzles and no difference could be noted in the power developed; the changed carbureter-adjustment for the high-speed nozzle was 24 notches, and for the low-speed nozzle it was 16 notches. On short trips over hilly country, a mileage slightly in excess of 20 miles per gal. was obtained; for city driving, it was from 16 to 19 miles per gal., depending upon the nature of the traffic.

RESULTS OF SERVICE-STATION ADJUSTMENT

In the fall of 1922, this car, service-station adjusted, was driven 1000 miles, mainly over level country and improved roads. Using the same grade of gasoline, a fuel consumption of 15.4 miles per gal. was obtained as compared with more than 20.0 miles per gal. in hilly country of which this car is capable. The load was the same on both trips. Hill-climbing ability with service-station adjustment was fair, and probably not 75 per

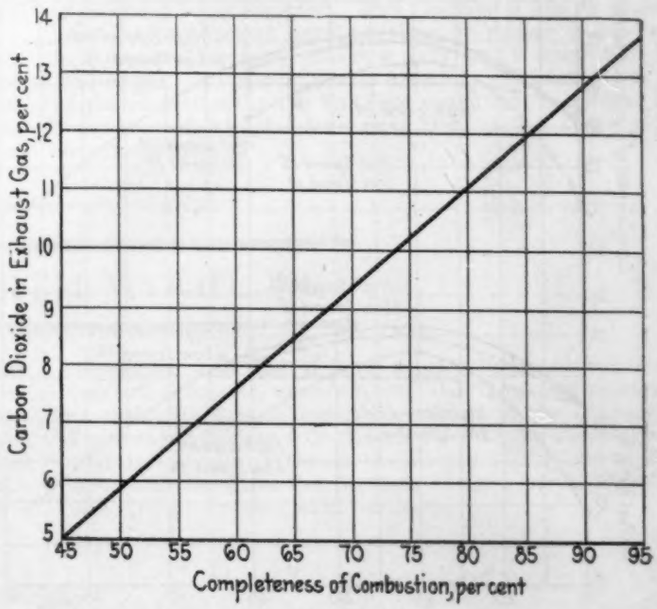


FIG. 2—CHART SHOWING THE RELATION BETWEEN THE PERCENTAGE OF CARBON DIOXIDE IN THE EXHAUST GAS AND THE PERCENTAGE OF COMPLETENESS OF COMBUSTION
This Chart Was Plotted from the Results of Tests Made in 1920 on 101 Automobiles of Six Representative Classes

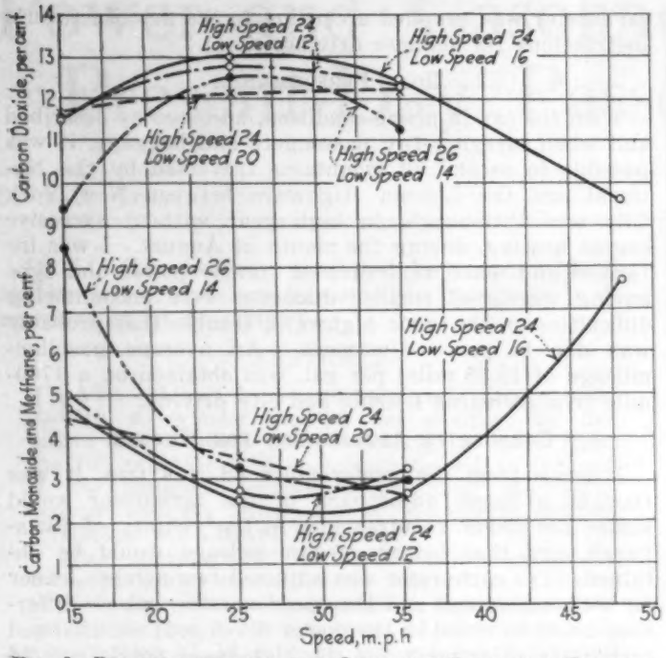

Carbon Dioxide, per cent
Carbon Monoxide and Methane, per cent
Speed, m.p.h.
High Speed 24 Low Speed 12
High Speed 24 Low Speed 16
High Speed 24 Low Speed 20
High Speed 26 Low Speed 14
High Speed 26 Low Speed 14
High Speed 24 Low Speed 16
High Speed 24 Low Speed 20
High Speed 24 Low Speed 12

FIG. 3—RELATION BETWEEN THE OPERATING SPEED AND EXHAUST-GAS CONSTITUENTS FOR VARIOUS LOW-SPEED-NOZZLE SETTINGS
In Obtaining the Data on Which These Curves Were Based Four Different Low-Speed Carbureter-Nozzle Settings Were Used

cent of the power capability was realized. The engine backfired rather frequently unless the choke was used slightly, which, in turn, resulted in a tendency toward oil-pumping and fouled spark-plugs. Carbon removal was necessary at the end of the 1000-mile run.

CARBON DEPOSITS AND PREIGNITION KNOCKS

When using the gasoline specified, with the engine scraped free from carbon and properly adjusted, no preignition knock or metallic "ping" was heard, regardless of the spark-lever position and the steepness of the grade ascended. When using lean mixtures, 26 carbureter notches for high-speed and 14 notches for low-speed jets, or leaner, and without the periodic use of kerosene to loosen carbon, sufficient carbon deposits existed at 1500 miles to cause a preignition knock or ping, which, at 2000 miles, became annoying when ascending long steep grades.

The extent to which carbon was deposited at 2000 miles by lean-mixture operation is shown in Fig. 1. The carbon in the valve-chambers was in the nature of a soot and, probably, from 0.005 to 0.007 in. thick. The carbon on the cylinder-heads and the pistons was of a shiny vitreous appearance and probably was a lubricating-oil carbon; it was of average egg-shell thickness and flaked-off in pieces about ¼-in. square when scraped.

CARBURETER-ADJUSTMENT STUDY BY EXHAUST-GAS ANALYSIS

That the percentage of carbon dioxide in the exhaust gas is a direct index of the efficiency of carbureter adjustment when an engine is adjusted properly and in good mechanical condition, was shown by tests made by the Bureau of Mines at its Pittsburgh Experiment Station and reported upon by A. C. Fieldner, A. A. Straub and G. W. Jones in a paper entitled Automobile Exhaust-Gases and Vehicular-Tunnel Ventilation.[2] The curve in Fig. 2 was developed from data obtained in these tests.

[2] See THE JOURNAL, April, 1921, p. 295.

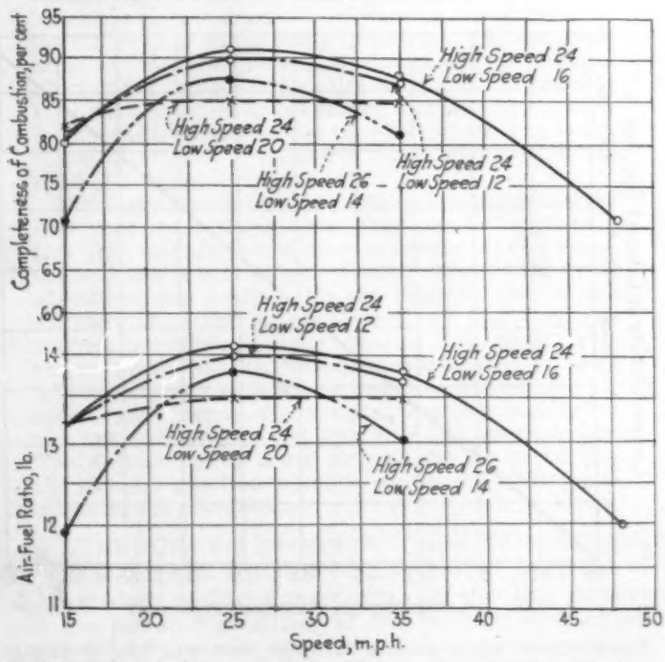

Completeness of Combustion, per cent
Air-Fuel Ratio, lb.
Speed, m.p.h.
High Speed 24 Low Speed 16
High Speed 24 Low Speed 20
High Speed 26 Low Speed 14
High Speed 24 Low Speed 12
High Speed 24 Low Speed 12
High Speed 24 Low Speed 16
High Speed 24 Low Speed 20
High Speed 26 Low Speed 14

FIG. 4—RELATION BETWEEN AIR-FUEL RATIO, COMPLETENESS OF COMBUSTION AND SPEED
The Same Low-Speed-Nozzle Settings as Were Used in Fig. 3 Gave the Data Plotted on This Chart

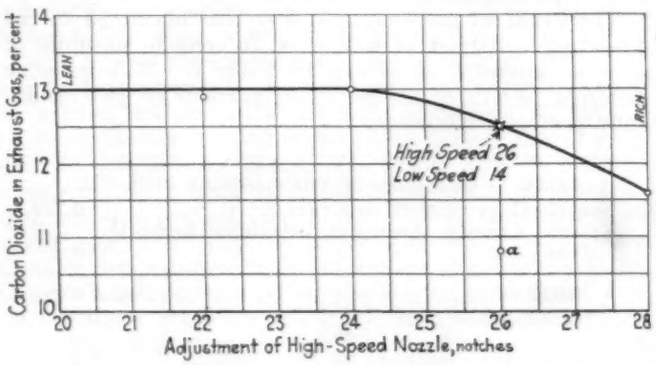


FIG. 5—EFFECT OF HIGH-SPEED-NOZZLE ADJUSTMENT ON THE CARBON-DIOXIDE CONTENT OF EXHAUST GAS
These Data Were Obtained when Operating at a Speed of 25 M.P.H. on a Level Road. Except as Noted the Low-Speed Nozzle Was Kept Constant at 16 Notches. The Point *a* Was Probably Due to an Error in the Sample

In view of the satisfactory results obtained with the leaner carbureter-adjustment, it was decided to study in detail the effect on the exhaust-gas analysis when operating this car at various speeds on a level road with the carbureter so adjusted. It was also desired to study the effect of adjusting the high-speed and the low-speed nozzles separately. All studies were made by exhaust-gas analysis.

The relation between operating speed and exhaust-gas constituents for various low-speed-nozzle settings is shown in Fig. 3. The relation between operating speed, air-fuel ratio by weight and by percentage and the completeness of combustion for various low-speed-nozzle settings is shown in Fig. 4. The effect on the carbon-dioxide content of the exhaust gas of various high-speed-nozzle adjustments when operating at 25 m.p.h. on a level road is shown in Fig. 5.

RESULTS ANALYZED

An analysis of the graphic presentation of the results shows that the carbon-dioxide content of exhaust gas,

the air-fuel ratio and the completeness-of-exhaustion curves are, as they should be, identical in character. Therefore, the carbon-dioxide content is a direct index of the efficiency of carbureter adjustment.

The negligible effect of low-speed-nozzle adjustment and the marked effect of high-speed-nozzle adjustment at a speed of 15 m.p.h. and greater are shown by Figs. 3, 4 and 5. These data corroborate the manufacturer's statement that the effect of the low-speed nozzle is relatively negligible at speeds in excess of 8 m.p.h.

A low-speed-nozzle adjustment of 20 notches provides too lean a mixture with which to idle the engine. The 12-notch adjustment is noticeably rich. The 16-notch adjustment causes the engine to idle evenly and gives the stipulated steady hiss in the carbureter.

No gain in economy is derived by an adjustment of the high-speed nozzle that is leaner than 24 notches, as shown in Fig. 5. Actual car-performance and later gasoline-measurement tests corroborate this conclusion.

These data show that the most economic driving-speed for this car is 25 m.p.h., and that its maximum economical operating speed-range is from 20 to 35 m.p.h.

Summary

When properly adjusted and handled, the present-day gasoline automobile will develop the power of which it should be capable and give high gasoline-mileage at the minimum of inconvenience and of service interruptions. The full capabilities of the machine will be realized if the manufacturer's instructions are adhered to rigidly in the maintenance and the adjustment of the engine.

Ceaseless "grinding" of the engine to start it in cold weather is not warranted if the engine and its appurtenances are in good condition and adjusted properly, and if the choke is used intelligently. Manufacturers should instruct their service-station attendants in the principles of combustion and as to the value of exhaust-gas analysis for the determination of the efficiency of carbureter adjustment. Also, the manufacturers should insist that service-station attendants time engines properly according to their instructions, and that they discontinue the listening, "guess-method" generally used. Checking carbureter adjustment by exhaust-gas analysis will eliminate the guess factor. An outstanding need exists for technical supervision of the work of service-station attendants and repairmen.

The poor condition and the wrong methods of operation of a great majority of present-day gasoline motorcars cause a National economic waste. Such waste should cease; it can cease, with benefit to all concerned. The results of the tests described show that intelligent application of basic principles resulted in a 30-per cent gasoline-mileage increase in operation, with increased power and flexibility attained at a lower maintenance cost and with less inconvenience. On the basis of a 30-per cent saving, and estimating gasoline at an average retail price of 25 cents per gal., the yearly conservation of the Nation's gasoline supply, calculated for the 1922 output of 6,202,235,000 gal., would have been 1,860,670,500 gal. which, at 25 cents per gal., totals $465,167,625. Truly, such savings are well worthy of consideration and attainment.

RUBBER

THE outstanding feature in the recent development of the rubber industry has been the phenomenal growth of the rubber plantations. Almost the entire output of raw rubber is now produced on plantations in southeastern Asia and the East Indian Islands. The largest producers are Malaya, the Dutch East Indies and Ceylon. Through either political sovereignty or ownership of plantations, the British control more than three-fourths of the output.

Although rubber is used in the manufacture of thousands of commodities, its consumption in the form of tires exceeds that in all other uses combined. More than three-fourths of the rubber imported into the United States goes into the manufacture of tires and tubes. The automotive, petroleum and rubber industries have developed together, with each dependent on the others.

The United States is by far the most important consumer of crude rubber, and takes normally about three-fourths of the world's supply. The great bulk of American rubber manufactures is consumed at home, only about 5 per cent of the total being exported. This Country is almost entirely dependent on foreign supplies, since no rubber is produced in American territory except a very small amount in the Philippines. In recent years American interests have acquired plantations in the Far East comprising something like 3 per cent of the total acreage in that part of the world.—*Guaranty Survey.*

E. ELLSWORTH WOOD, JR.

IN a recent notice from the Miniature Incandescent Lamp Corporation, Newark, N. J., announcement is made of the death on Dec. 2, 1924, of Elmer Ellsworth Wood, Jr., who was in charge of its engineering department, aged 26 years. Mr. Wood was born on June 26, 1898, at Newark, N. J., and entered the service of this company in 1918, in an engineering capacity. His subsequent work for the company was cooperative with that of lamp manufacturers on new standards of headlamp specifications and lamp engineering in general. He was an associate member of the Illuminating Engineering Society. On March 15, 1921, he was elected to Associate Member Grade in the Society of Automotive Engineers, and served on the Lighting Division of the Standards Committee from 1922 until his death.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Nov. 10 and Dec. 10, 1924. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ABBOTT, HENRY L. (M) automotive engineer, International Motor Co., New York City, (mail) 81 South Parsons Avenue, *Flushing, N. Y.*

ALLEN, EDMUND TURNEY (M) aeronautical engineer and consultant, (mail) Cosmos Club, *City of Washington.*

AMES, AUBREY P. (A) lubrication engineer, Standard Oil Co. of New York, *Manila, P. I.*

BEHNING, EDWARD F. (A) engineer in gear division, Diamond State Fibre Co., Bridgeport, Pa., (mail) 425 Insurance Exchange Building, *Detroit.*

BURR, F. H. (A) director of automotive division, Cleveland Pneumatic Tool Co., 3734 East 78th Street, *Cleveland.*

CAMPBELL, CAPT. ALAN L., (S M) office of the Adjutant General, City of Washington, (mail) *Fort Sill, Okla.*

CHOU, CHENG-YU (J) draftsman, Pierce Arrow Motor Car Co., *Buffalo,* (mail) 344 Richmond Avenue.

CLARK, MAURICE E. (A) engineer, Bunting Brass & Bronze Co., Toledo, (mail) 5517 West Ohio Street, *Chicago.*

DICK, JOSEPH (A) manager of general parts service division, Durant Motors of Canada, Ltd., Leaside, *Toronto, Ont., Canada.*

DONALD, ALEXANDER (A) manufacturer, Canada Wire & Iron Goods Co., 180 King William Street, *Hamilton, Ont., Canada.*

FELL, LEONARD (A) vice-president and production manager, Burton-Fell Co., 3341 Jefferson Avenue, East, *Detroit.*

FRANCIS, DEAN D. (J) assistant superintendent, Marvel Carburetor Co., *Flint, Mich.,* (mail) 727 East Street.

FREDERICH, CHARLES W. (J) test engineer in standards department, General Motors Corporation, Detroit, (mail) Norman Court Apartments, 12,245 Hamilton Avenue, *Highland Park, Mich.*

GOETZ, JULIUS J. (A) president and treasurer, Western Metal Specialty Co., 3020 Calhoun Place, *Milwaukee.*

GRABOSKI, LEO D. (M) mechanical engineer, Vulcan Iron Works, 730 South Main Street, *Wilkes Barre, Pa.*

GUAY, E. J. (M) engineer in fabroil gear department, General Electric Co., River Works, 920 Western Avenue, *Lynn, Mass.*

HARRIS, SIDNEY G. (J) sales engineer covering factory branch and dealer trade, Metropolitan Body Co., Long Island City, N. Y., (mail) 601 West 174th Street, *New York City.*

HEIDER, HARVEY B. (M) engineer, secretary and treasurer, Luce Cane Harvester Corporation, Room 1104, 1540 Broadway, *New York City.*

HILL, J. BENNETT (M) chief research chemist, Atlantic Refining Co., 3144 Passyunk Avenue, *Philadelphia.*

JOHNSON, THOMAS B. (A) superintendent of garages, Marshall Field & Co., *Chicago,* (mail) 601 West Polk Street.

KAYE, LEROY A. (J) assistant engineer in carbureter division, Stewart-Warner Speedometer Corporation, 1826 Diversey Boulevard, *Chicago.*

KELLY, LEO ALFRED (A) special representative, Motor Wheel Corporation, *Lansing, Mich.,* (mail) 3044 Calvert.

KESSING, ALBERT F. (M) secretary and treasurer, Porterville Machine Works, Inc., *Porterville, Cal.,* (mail) 510 West Bellview Avenue.

KNOOP, OSKAR (F M) director of engineering, Nationale Automobil-Gesellschaft, Berlin-Aktiengesellschaft, *Oberschoneweide, Germany.*

LAPSLEY, JOHN ALEXANDER (A) automotive engineer and draftsman, Yellow Coach Mfg. Co., *Chicago,* (mail) 6829 Throop Street.

LAWTON, HOWARD B. (A) general manager, Clark Cutter Co., *Detroit,* (mail) 5546 Dailey Avenue.

LEPAGE, W. LAURENCE (J) aeronautical engineer and research associate, department of aeronautics, Massachusetts Institute of Technology, *Cambridge, Mass.*

LOSEE, JAMES R. (A) resident engineer, C.M.S., Inc., *Tarrytown, N. Y.,* (mail) 89 Altamont Avenue.

LOWE, EDWARD F. (A) general manager, K. P. Products Co., 60 Beaver Street, *New York City.*

LUTEN, DANIEL B. (A) president, Luten Engineering Co., *Indianapolis,* (mail) 1056 Consolidated Building.

MCGINNIS, P. B. (A) sales and engineering representative, Westinghouse Air Brake Co., Wilmerding, Pa., (mail) 827 Railway Exchange Building, *Chicago.*

MCPHERSON, C. J. (M) sales manager, automotive car division, J. G. Brill Co., *Philadelphia.*

MARLEY, SAMUEL P. (M) research fellow, Mellon Institute of Industrial Research, *Pittsburgh.*

MORRISON, JOE W. (A) patent department, General Motors Corporation, New York City, (mail) 604 McGill Building, *City of Washington.*

PAXTON, SAMUEL M. (A) president, S. M. Paxton Co., 328 Union Building, *Cleveland.*

RADLER, JOSEPH C. (M) engineer, 2115 41st Avenue, *Oakland, Cal.*

REID, ELLIOTT GRAY (J) assistant aeronautical engineer, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

RICHARDSON, CHARLES EDWARD (A) draftsman and assistant to general manager and engineer, Duro Co., Newark, N. J., (mail) 182 North 16th Street, *East Orange, N. J.*

SHERIDAN, JOHN J. (A) service manager, Rolls-Royce of America, Inc., 951 South Flower Street, *Los Angeles.*

SHERWOOD, E. H. (A) salesman, National Malleable & Steel Castings Co., 10,600 Quincy Avenue, *Cleveland.*

SMITH, C. H. (A) vice-president, Westinghouse Union Battery Co., Swissvale Station, *Pittsburgh.*

TIMPF, CHARLES R. (A) chief inspector, Spicer Mfg. Corporation, *Pottstown, Pa.,* (mail) 351 North Charlotte Street.

TREIBER, OTIS D. (M) charge of engineering and sales, Diesel engine division, Bessemer Gas Engine Co., *Grove City, Pa.*

TRUMP, CHARLES C. (M) engineer of tests, Atlantic Refining Co., 3144 Passyunk Avenue, *Philadelphia.*

UNDERHILL, HAROLD (J) draftsman and assistant to chief engineer, United Motors Products Co., *Grand Rapids, Mich.,* (mail) 315 Barclay Avenue, Northeast.

WALBRAN, NICHOLAS A. (J) assistant engineer, Bossert Corporation, Utica, N. Y., (mail) *Oriskany, N. Y.*

WHELAN, W. MILLER (A) oil engine designer and draftsman in shop engineering department, Fairbanks, Morse & Co., 552 Public Avenue, *Beloit, Wis.*

WOODWORTH, FRANK A. (M) automotive transportation engineer, Henry L. Doherty & Co., 60 Wall Street, *New York City.*

Applicants *for* Membership

The applications for membership received between Nov. 15 and Dec. 15, 1924, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ACKER, GEORGE H., engineer, Cleveland Worm & Gear Co., *Cleveland.*

AHRENS, WILLIAM H., automobile mechanic's instructor, *Englewood, N. J.*

ALLEN, EDWIN L., JR., checker and designer, Cleveland Automobile Co., *Cleveland.*

ANDREWS, D., service-manager, Continental Motors Corporation, *Detroit.*

ANGELERY, HENRY W., assistant buyer in machinery department, Mitsubishi Co., Ltd., *New York City.*

BARNES, FULLER F., general manager, Wallace Barnes Co., *Bristol, Conn.*

BARNHART, EDGAR W., general engineer, Osgood Co., *Marion, Ohio.*

BEAUBIEN, JAMES L., service supervisor, Paige Detroit Motor Car Co., *Detroit.*

BECKER, CHARLES F., supervisor of engine testing laboratory, Associated Oil Co., *Associated, Cal.*

BOOTH, C. A., service-manager, E. V. Stratton Motors, *Albany, N. Y.*

BUITENHUIS, C. H., mechanical engineer, 32 Fornelius Avenue, *Athenia, N. J.*

BURCH, LYNDON W., service and sales, Packard Motor Car Co., *New York City.*

BURNSIDE, FRANK E., superintendent, California Highway Commission, *Sacramento, Cal.*

BUTLER, HOWELL H., designer, White Motor Co., *Cleveland.*

CROMLEY, W. W., assistant general manager, Stearns Motor Mfg. Co., *Ludington, Mich.*

DARLING, FORD O., sales manager, Field Body Corporation, *Owosso, Mich.*

DEEBLE, WILLIAM RILEY, 55 East Mosholu Parkway, North, *New York City.*

DE GANAHL, CARL, works manager, Medway Oil & Storage Co., Ltd., *Isle of Grain, Kent, England.*

DORN, R. V., draftsman, Kimball Motor Truck Corporation, *Los Angeles.*

DUNLAP, ERNEST A., superintendent of service, Auto Electric & Service, *Detroit.*

ESSELSTYN, HORACE H., engineer, Carey & Esselstyn, *Detroit.*

FELDMAN, WILLIAM, district service-manager, American Bosch Magneto Corporation, *Detroit.*

FOX, JOHN H., executive engineer, Pittsburgh Plate Glass Co., *Pittsburgh.*

FRASER, EWEN J., shop superintendent, Baltimore Transit Co., *Baltimore.*

GETLER, CHARLES, vice-president, C. G. Spring & Bumper Co., *Detroit.*

GRIMES, CHARLES F., foreman test and repair department, Chevrolet Motor Co., *Janesville, Wis.*

HOENINGHAUSEN, LAVERETTE, draftsman and tool designer, International Motor Co., *New York City.*

HWA, YING-SAING, inspector, Packard Motor Car Co., *Detroit.*

JACKSON, J. B., assistant to vice-president, General Motors Corporation, *Detroit.*

JOHNSON, ROBERT LEROY, sales engineer, Mullins Body Corporation, *Salem, Ohio.*

JOSEPHSON, WALTER S., first vice-president and general manager, Prest Air Corporation, *New York City.*

LAMB, F. R., methods and standardization department, Studebaker Corporation of America, *Redford, Mich.*

LAMPMAN, GEORGE W., designer, Brooks Steam Motors, *Stratford, Ont., Canada.*

LICHTENBERG, ERICH HERMAN, chief engineer, Koehring Co., *Milwaukee.*

LUCAS, JOHN H., superintendent of rolling stock, Milwaukee Electric Railway & Light Co., *Milwaukee.*

LYON, GEORGE A., service-manager, American-LaFrance Fire Engine Co., *Boston.*

MARTIN, WATSON E., superintendent, Baltimore Transit Co., *Baltimore.*

MEYBEM, EDWARD, master mechanic, City of Berkeley, *Berkeley, Cal.*

MEYER, FRANK A., sales promotion, Milwaukee branch, Ford Motor Co., *Milwaukee.*

MILLS, JOHN W., managing director, Halleys Industrial Motors, Ltd., *Yoker, Scotland.*

MOON, STANLEY, secretary, Moon Motor Car Co., *St. Louis.*

MORSE, PHILIP H., manager and proprietor, Syracuse Garage Co., *Syracuse, N. Y.*

NOEL, GEORGE A., service-manager, Toronto Durant Co., Ltd., *Toronto, Ont., Canada.*

OSTRANDER, A. E., assistant vice-president, American Car & Foundry Co., *New York City.*

OTIS, J. E., JR., vice-president, Bassick Mfg. Co., *Chicago.*

PAGE, RAYMOND D., engineer, Precision Casting Co., *Fayetteville, N. Y.*

PRICE, GEORGE E., production engineer, Phoenix Stone Co., *Arrington, Va.*

RATTRAY, WILLIAM E., salesman, National Malleable & Steel Casting Co., *Chicago.*

RECORD, JAMES L., chairman of the board of directors, Minneapolis Steel & Machinery Co., *Minneapolis.*

REID, PERCY H., service-manager, Benson Manley, Ltd., *Montreal West, Que., Canada.*

SEE, PIERRE V. C., superintendent of equipment, Northern Ohio Traction & Light Co., *Akron, Ohio.*

SETTLES, H. L., draftsman, Kimball Motor Truck Corporation, *Los Angeles.*

SHERMAN, S. B., general superintendent, Wisconsin Gas & Electric Co., *Racine, Wis.*

SIERK, HERBERT, sales representative, *Houston, Tex.*

SLOAN, JOHN A., manager, International Motor Co., *New York City.*

SLOANE, W. W., assistant to chief engineer, Goodman Mfg. Co., *Chicago.*

SMITH, L. M., engineer, Vacuum Oil Co., *New York City.*

SOULEN, HARRY B., head of development and tire testing, Federal division, Fisk Rubber Co., *Cudahy, Wis.*

THIRLWALL, J. C., engineer, General Electric Co., *Schenectady, N. Y.*

WAGNER, VICTOR W., service representative, Studebaker Corporation of America, *South Bend, Ind.*

WILLIAMSON, E. D., manufactures representative, Mid-Western Sales Corporation, *Detroit.*

YINGLING, J. C., assistant to chief engineer, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

ZELLER, FIRST-LIEUT. HARRY L., Quartermaster Corps, *Honolulu, T. H.*